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JOURNAL OF ECONOMIC ENTOMOLOGY

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Soil Moisture and Its Relation to the Mortality of *Hypoderma* Pupae

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Considerable attention has been given to the effect of temperature and moisture on insect development. Practically all available moisture records have reference to atmospheric moisture. No literature has been found showing accurate records of the effect of continuous contact moisture on the development of pupae of cattle grubs, *Hypoderma* spp. Many insects pupate in the soil or in some other medium where the moisture content is independent of, and dissimilar to, the atmospheric moisture. Therefore that particular environment cannot be adequately measured by reference to climatological data, especially in relation to moisture. Soil moisture is a controlling factor in the development of *Hypoderma* pupae.

Bishopp *et al.* (1926) state that no cattle grubs were found in cattle on low, swampy ground. According to Smith (1932), cattle grubs are more numerous in Kansas after a dry spring than after a wet one. Fletcher & Sen (1930) write that "Warble infection . . . would appear to be, as a rule, restricted to Northwestern India and absent from the moister areas, such as Madras, Assam, Burma and Ceylon." Commenting upon the abundance and distribution of *Hypoderma* in Poland, Stefanski & Obitz (1935) state that in 1934 the cattle had fewer grubs than during the previous year, probably because of the numerous rains in the summer of 1933.

Scarcity of Cattle Grubs in the Red River Valley of the North.—Cattle grubs, *Hypoderma bovis* DeG. and *H. lineatum* (DeVill.), are found throughout the United States, but there are certain areas where they are scarce or periodically absent. Most of these areas are small and scattered, but there is one large area, the Red River Valley of the North, where, under average climatic conditions, cattle grubs are entirely absent. To most stockmen of this area, cattle grubs are unknown. Quite naturally the question arises, What factor or set of factors is responsible for the scarcity of cattle grubs in this area? This question was studied by the Bureau of Entomology from 1929 through 1932. Apparently the dominant controlling factor is excessive soil moisture.

Information relative to the presence or absence of grubs in the Red River Valley and surrounding territory was gathered from stockmen, county agents and, more especially, by direct examination of cattle. The large grub-free area was found to be confined to the Red River Valley of the North, an old lake bed formed in glacial Lake Agassiz, more specifically between the first or inner banks of the extinct glacial lake. The greater portion of this marginal lake was in Manitoba, Canada, and extended into the United States, covering eastern North Dakota, western Minnesota and northeastern South Dakota. According to Upham (1896), at the close of the glacial period in North America there was a regression northward of the vast mass of ice. When the borders of the ice receded beyond the watershed which divided the basins of the Minnesota and Red Rivers, it left a marginal lake that was formed by the melting glacier. As the ice receded along the Red River Valley the lake followed, filling the valley to a level with a forced southern outlet. The recession of the lake, after finding its natural outlet to the north, left that portion of the old lake basin in the United States a level, fertile

valley. Such topography retards the escape of surface water to streams, the banks of which are often higher than the surrounding territory.

The Red River Valley of the North is a vast plain of glacial drift and lacustrine and fluvial deposits (Willard & Fuller 1927), 40 to 50 miles wide and exceeding 300 miles in length, extending from Lake Traverse in Minnesota to Lake Winnipeg, Canada. Its uniform, continuous downward slope to the north averages less than 1 foot per mile, while the rise eastward and westward from Red River is 2 to 3 feet per mile for the first 10 to 15 miles. The predominating soil type is Fargo clay (Hopper & Walster 1924), known locally as gumbo—a heavy, black clay, plastic when wet and granular when dry, underlain with a heavy, waxy, calcareous subsoil (Hopper, Nesbit & Pinckney 1931), impervious to moisture. Fargo clay has little surface or sub-surface drainage; so during periods of heavy rainfall it becomes saturated and remains wet for weeks, fig. 1.

FIG. 1.—Typical topography of the Red River Valley of the North. Note lack of drainage.

In central and western North Dakota cattle grubs are found in the backs of cattle from the latter part of February until early in June. There appear to be two crops of grubs. In reality there are two species of *Hypoderma* which make their appearance at different times—the common cattle grub, *H. lineatum*, appearing in February, and the northern cattle grub, *H. bovis*, appearing the latter part of March. The relative abundance of the two species varies from year to year, the variations being due, apparently, to climatic conditions.

Upon reaching maturity the cattle grubs leave the host, drop to the ground, and crawl into the soil or under debris, where they pupate. The pupal period ranges from 17 to 38 days. At the time the grubs drop from the backs of cattle in the Red River Valley, they fall upon frozen ground or upon a very wet soil. These investigations have shown that grubs which drop upon a saturated soil fail to pupate and subsequently die. Under average conditions the accumulation of rain, sleet and snow from the first freeze in the fall until the thaws late in the spring provides more than enough moisture to saturate the soils of the Valley, and the spring rains keep the soil wet until after the emergence period of *Hypo-*

derma adults. During the vegetative season the moisture content of the soils in the Valley has been found by Doneghue (1918) to range from 25.9 to 43 per cent. During the spring, however, these soils contain an even greater amount of moisture.

Field experiments showed that although *Hypoderma* pupae would not develop in wet soils, the same soils, provided with ample drainage, would permit complete development and adult emergence. These results were confirmed by laboratory experiments conducted in a greenhouse at Fargo, N. D.

LABORATORY EXPERIMENTS WITH CATTLE GRUB PUPAE AT AMES, IOWA.—Experiments with *Hypoderma* pupae in soils of known moisture content were conducted at Ames, Iowa, during 1933 and 1934. In the preparation of the soils, about 1 inch of fine sand was placed in the bottom of a butter crock 4 inches deep and 6 inches wide, a glass tube one-half inch in diameter and 7 inches long was placed upright in the center, and 700 grams of oven-dry loam soil was added, fig. 2. The calculated amount of water to make up the desired percentage of soil moisture was added through the glass tube. The total weight of each crock and its contents was recorded, thereafter weighed daily, sufficient water being added to maintain the designated moisture content. The crocks were kept in a screened insectary, protected from the sun and rain. Ten *H. bovis* pupae were buried one-fourth inch deep in each soil. Evaporation of soil moisture was lessened by the addition of chopped straw to the surface of the soil. A piece of cotton netting was fitted over each crock to retain adult flies as they emerged.

At the conclusion of the experiment, soil samples from each crock were dried in an oven for 20 hours at 107 degrees C. and the soil-moisture content ascertained according to the method of Lyon & Buckman (1922). The results are shown in table 1.

The results of this experiment show that *H. bovis* will not mature in soils containing more than 22 per cent of moisture.

Supplementing the foregoing experiment, a soil was maintained with an excess of free water on the surface. Five pupae of *H. bovis* were half-buried in the soil with the posterior end protruding above the soil and water; and five pupae were half-buried with the posterior end down. Flies developed in all puparia with posterior end up, but only one fly emerged. None of the other pupae developed.

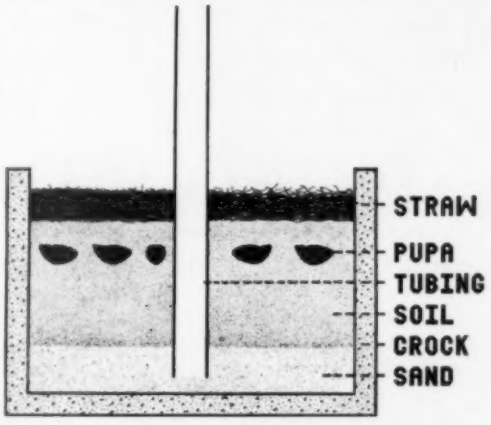

FIG. 2.—Cross section of soil-water experiment with *Hypoderma* pupae.

In another experiment, a screen-wire platform was placed in a butter crock and the crock filled with water to within one-fourth inch of the platform. Five pupae and five larvae of *H. bovis* were placed on the platform and the crock covered with four thicknesses of cheesecloth. Ten flies developed, and nine of them emerged.

Experiments with pupae of *H. linea-*

Table 1.—Emergence of *Hypoderma bovis* from pupae (10 in each lot) in loam soils of various water contents.

No.	PER CENT WATER	PER CENT EMERGENCE
1	1.46	100
2	1.47	100
3	3.98	100
4	4.16	100
5	12.53	40
6	13.83	30
7	14.39	20
8	22.70	0
9	28.60	0
10	29.35	0
11	30.38	0
12	31.34	0
13	34.46	0
14	34.51	0
15	49.24	0
16	52.01	0
17	61.36	0

Table 2.—Emergence of *Hypoderma lineatum* from pupae (five in each lot) in loam soils of various moisture contents.

No.	Per Cent Water	Per Cent Emergence
1	0.86	100
2	2.72	100
3	4.66	100
4	7.05	40
5	10.58	0
6	11.27	0
7	11.67	0
8	11.69	0
9	12.93	0
10	16.05	0

tum in soils of various moisture contents were conducted in the same way, except that the pupae were buried one-half inch and only five pupae were placed in each crock. The results are shown in table 2.

The results of this experiment show 100 per cent emergence of pupae in soils containing less than 5 per cent of moisture, 40 per cent emergence from pupae in soils containing 7 per cent of moisture and no flies developing from 30 pupae in soils containing over 10 per cent of moisture. No flies developed from five pupae buried one-half inch in saturated soil, no flies developed from two pupae half-buried in saturated soil with posterior end down and two flies developed (only one emerged) from two pupae half-buried in saturated soil with posterior end up. Three flies developed and emerged from two pupae and one larva placed on a screen platform one-fourth inch above water.

CONCLUSION.—From these data it is evident that *Hypoderma* pupae will not develop in soils having a moisture content in excess of 20 per cent. The exact minimum soil moisture content that produces mortality of *Hypoderma* pupae has not been ascertained but probably varies with the type of soil, and very likely, is not in excess of the hygroscopic coefficient.—2-18-38.

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The Screwworm and the Gulf Coast Tick in Southern Texas

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In southern Texas, where the screwworm, *Cochliomyia americana* C. & P., is active throughout the winter months, the dry weather and the high atmospheric temperatures late in the summer and in the autumn of 1937 resulted in a high degree of natural control of the pest. This was most noticeable in counties away from the coast and was of less consequence in the coastal section, where the

conditions appeared more favorable for screwworm infestations in different kinds of injuries.

One type of injury, that caused by the attachment of the Gulf Coast tick, *Amblyomma maculatum* Koch. to the ears of animals, was accompanied by much soreness, and when such untreated wounds were infested with screwworms they forcibly impressed upon stockmen the seriousness of the combined injuries by these two parasites. Bishopp & Hixson (1936) have shown that this joint problem of screwworms and ticks extends along the Gulf Coast and the Atlantic Coast of the southern States. Stockmen who fail to apply preventive measures for control of the ticks later find it necessary to treat the animals carefully for both pests. It is then advisable to restrain the animals on the ground in order to kill screwworms in the ear wounds, and in this treatment much labor is required. After the severe infestations have been treated the animals should be kept in hospital pastures for subsequent treatments.

The data in this paper show (1) that cases of screwworms were more numerous along the coast than inland, (2) that the problem of controlling screwworms in southern Texas involves also the problem of controlling the Gulf Coast tick and (3) that it is highly desirable to adopt practices which will keep to a minimum the infestations of both ticks and screwworms.

PROCEDURES.—During the cooperative campaign of 1936 for control of screwworms, supervisors called upon ranchmen, gave demonstrations on methods of control, received detailed reports of the occurrence of cases, their causes and the number of animals represented, and collected specimens of screwworms and ticks for identification. In 1937 similar records were obtained, but on a reduced scale. On the basis of reports received for July, August, September and October for 1936 and 1937, and from additional information obtained from stockmen during these periods, it is possible to compare the average rates of occurrence of cases of screwworms per 100,000 animals for the coastal counties with those of the adjoining areas in southern Texas.

INCIDENCE OF SCREWWORM CASES IN TEXAS, 1936 AND 1937.—From July 1 to December 31, 1936, 103,574 cases of screwworms were reported from 152 counties in Texas, an average rate of 825 cases per 100,000 animals in these counties. For a comparable period in 1937, 24,361 cases were reported from 100 counties in Texas, an average rate of 392 cases per 100,000 animals, table 1. This reduction of more than one-half in the rate of occurrence of cases is attributed to the combined results of (1) the demonstrational program by screwworm-control supervisors during the latter part of 1936 and (2) additional work by supervisors in the southern counties in Texas during the winter months, when screwworms usually develop a population of parent flies for the following year, (3) special work to insure treatment of cuts during the shearing of sheep and goats in the spring of 1937 and (4) the dry weather in southern counties away from the coast. The railroad companies recognized the drought and made concessions in transportation rates on shipments of feeds and animals to and from 23 southern counties.

Table 1.—The average rates of occurrence of cases of screwworms in all infested counties in Texas, in southern coastal counties and in southern counties away from the coast, for 1936 and 1937.

PERIOD	NUMBER OF COUNTIES	NUMBER OF CASES REPORTED	AVERAGE RATE PER 100,000 ANIMALS	LOCATION OF COUNTIES
July–Dec., 1936	152	103,574	825	Statewide
July–Oct., 1936	13	10,768	1,260	Coastal—Matagorda to Cameron
July–Oct., 1936	12	5,946	1,148	Away from coast
July–Oct., 1937	12	1,782	126	Away from coast
July–Oct., 1937	9	7,216	745	Coastal and most southern
July–Dec., 1937	100	24,361	392	Statewide

INCIDENCE OF SCREWWORM CASES IN SOUTHERN COUNTIES, 1936.—From July to October, 1936, inclusive, the incidence of screwworm cases in the southern coun-

ties of Texas was about one-third greater than the average for all infested counties of the state, and the rate in the littoral counties was about 10 per cent greater than that in the inland counties. For 152 counties, during six months, there was an average rate of 825 cases; during four months in 13 counties in the coastal area, extending from Matagorda County to Cameron County, there was an average rate of 1,260 cases; and in southern counties away from the coast there was an average rate of 1,148 cases in 100,000 animals.

INCIDENCE OF SCREWWORM CASES IN SOUTHERN COUNTIES, 1937.—From July to October, 1937, inclusive, there was a reduction in the incidence of cases as compared with this period of the preceding year, but there was a greater difference between the coastal counties and those more distant from the coast. From nine counties (Brooks, Cameron, Hidalgo, Jim Wells, Kenedy, Kleberg, Nueces, Starr and Willacy) 7,216 cases were reported, an average rate of 745 cases in 100,000 animals. In 12 southern counties more distant from the coast there were 1,782 cases, an average rate of 126 cases in 100,000 animals.

SIGNIFICANCE OF DIFFERENCES IN INCIDENCE IN SOUTHERN COUNTIES, 1936 AND 1937.—In 1936 the average rate of infestation of 1,260 in the coastal area was about one-tenth higher than the average rate of 1,148 in the counties away from the coast. In 1937 the average rate in the coastal area was 745 and in counties away from the coast it was 126 in 100,000 animals. These rates show very clearly that screwworms maintained a population along the coast, even though that portion of the state experienced a general drought. The rates of occurrence in the two areas also suggest that, if full advantage is to be taken of dry weather in the future, it will be necessary to adopt year-around practices which will keep to a minimum the screwworm infestations occurring in the coastal section.

SCREWWORMS IN INJURIES PRODUCED BY THE GULF COAST TICK IN SOUTHERN TEXAS.—During 1936 there were reported from 152 counties in Texas 104,376 infestations of screwworms, of which 10,119, or 9.69 per cent, were attributed to tick bites. These cases were not of widespread occurrence in the state but were restricted to an area within about 100 miles of the coast. Approximately three-fifths (6,224 cases) of all such cases occurred in 13 adjoining counties on the southern coast of Texas during a period of four months, table 2. In July 710 cases were reported in this area, of which 110, or 15.49 per cent, were due to tick bites; in August 3,955 cases, of which 2,399, or 60.66 per cent, were due to tick bites; in September 2,896 cases, of which 1,900, or 65.61 per cent, occurred in tick bites; and in October 3,207 cases were reported, of which 1,815, or 56.59 per cent, were due to tick bites. For the period of four months 10,768 cases were reported, and 6,224, or 57.80 per cent, of these were attributed to bites of the Gulf Coast tick.

Table 2.—Screwworm infestations in bites of the Gulf Coast tick in southern Texas.

Area	July	August	September	October	July to October		
	Per Cent in Tick Bites	Per Cent in Tick Bites	Per Cent in Tick Bites	Per Cent in Tick Bites	Total Cases Reported	Cases in Tick Bites	Per Cent in Tick Bites
13 counties, 1936	15.49	60.66	65.61	56.59	10,768	6,224	57.80
9 counties, 1937	3.16	10.85	59.04	55.08	7.216	1,579	21.88

Reduction of Cases, 1937.—A marked reduction of screwworm cases in injuries produced by ticks during 1937 is attributed largely to the work of stockmen in treating the ears of animals. In nine counties a total of 7,216 cases of screwworms were reported in all types of injuries from July to October, inclusive, and 1,579 infestations, or 21.88 per cent of the reported cases, were in tick bites. When compared with 57.80 per cent, it is seen that the reduction amounted to five-eighths of the percentage for the previous season. By referring to table 2 it will be noted that the greatest reduction occurred during the months of July and August, and that September and October, which represented more arid condi-

tions, were much more favorable for such cases.

Neglect of Preventive Treatments.—Although there was a marked reduction in the infestations in tick bites, which was directly associated with the practice of swabbing the ears of animals for prevention of both ticks and screwworms, some stockmen neglected to carry out the recommended treatments and were confronted with serious infestations by both parasites. In Refugio County during August, 1936, and in Aransas, Calhoun, Hidalgo and Refugio counties during September, 1936, from 81.2 to 90.8 per cent of all screwworm cases occurred in tick bites. In September, 1937, 89.3 per cent of the cases in Brooks County and 85.4 per cent of the cases in Willacy County were attributed to tick bites. In October 1937, 91.6 per cent of the cases in Brooks County were associated with such injuries.

Inquiries and records of cases made in counties farther north on the coast support the opinion that the early cases usually occur about July 15 and that the highest incidence was from August 15 to September 15. In September, 1937, among 6,000 cattle on one ranch near Refugio, it was estimated that 500 screwworm cases were in tick bites; near Vidauri about 350 cases were being treated on one ranch, and on an adjoining ranch about 30 cases were treated each day in August and September. In Calhoun County one rancher near Bloomington had more than 500 screwworm-tick bite cases in two hospital pastures during September. In Jackson County 150 cases were observed early in October in two corrals of one ranch.

Difficulties Resulting From Neglect.—When tick-bite wounds were infested with screwworms, the stockman found it difficult to treat the infestations rapidly. In order to kill all of the screwworms it was necessary to restrain the animal for several minutes so that it could not shake its head and cause the cotton plug to drop to the ground. The stockmen also found that proper treatment of these cases was a tedious procedure which required much labor in handling the animals, and that, further, it was advisable to keep the animals where they could be given additional treatments until the wounds healed.

Preventing Tick Bites.—When pine-tar oil is applied to the ears of animals it repels ticks for as long as 17 days, kills the ticks that are present at the time of treatment, repels screwworm flies from laying eggs for periods of one to four days and aids the healing of the wounds. If stockmen make regular treatments of the ears of all animals and begin the work with the first occurrence of Gulf Coast ticks, the joint infestations of ticks and screwworms are kept to a minimum. If these preventive treatments are delayed until after the ears are infested with screwworms, the ears are sensitive, and it is more difficult to reach the inner portions with hand-smeared applications. A mixture consisting of 3 quarts of pine-tar oil and 1 quart of cottonseed or linseed oil is recommended for use on the ears of all animals. If one pint of benzol is added to each gallon of the mixture it will kill ticks in less time, will aid in killing small screwworms and will insure a more even spread of the oil on the skin of the ear.

If screwworms are permitted to develop in injuries caused by Gulf Coast ticks, they will have opportunities, in shipments of calves, to reach other southern localities where some of them may survive the winter and where they may invade new territory. The problem of controlling both Gulf Coast ticks and screwworms is of paramount importance for the cattleman in the coastal areas as well as for stockmen receiving animals from this section.

SUMMARY.—For July to December, 1936, inclusive, the average rate of occurrence of screwworm cases in Texas was 825 per 100,000 animals, and for a comparable period of 1937 the average rate was 392.

In 1936 the average rate of cases from July to October, inclusive, in the counties along the southern coast of Texas was almost 10 per cent greater than the rate for inland counties in the southern part of the state. In 1937 the average rate of cases from July to October, inclusive, along the southern coast and the rate in counties away from the coast show reductions from those of the preceding year and marked differences between the two areas for 1937, indicating that the drought in the southern portion of the state in 1937 was less effective in controlling screwworms in the coastal section than in inland counties.

The cases of screwworms in tick-bite injuries in 152 counties of Texas from July

to December, 1936, represented 9.69 per cent of all screwworm cases reported. Approximately three-fifths of the cases in tick bites occurred in 13 counties of the southern coast during July, August, September and October, and these cases represented 57.8 per cent of all reported screwworm cases in these counties. During the July–October period of 1937, 21.88 per cent of the screwworm cases in nine counties occurred in tick-bite wounds. The highest incidence occurred in September and October, when it appeared that dry weather was favorable for ticks and for screwworm cases in wounds caused by tick bites.

Intensive control of Gulf Coast ticks is needed for the reduction of screwworm cases in the Gulf Coast area, so that (1) protection will be afforded stock owners in this area, (2) the natural control due to droughts may be utilized more fully, (3) reduced numbers of screwworms will pass the winter and (4) there will be less opportunity for screwworm cases to be shipped from the tick-infested area into distant territories in the fall of the year.—2-18-38.

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The Incidence and Importance of *Cochliomyia americana* and Other Wound-Invading Species*

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Authentic identifications of a large number of collections of larvae obtained from wounds throughout the infested area over a long period of time serve as a logical index to the incidence and relative importance of the more common myiasis-producing species of flies. The data presented herein leave much to be desired as regards the present status of the screwworm, but they are in accord with reports by Knipling & Rainwater (1937) for 1935, and they furnish further evidence that the screwworm control problem is essentially one of controlling *Cochliomyia americana* C. & P.

Following the appearance of a paper in 1933 in which *Cochliomyia americana* was described by Cushing & Patton (1933), screwworm control recommendations were modified to conform to the idea that this species is an obligatory parasite. Intensive research and field observation confirmed the evidence at hand indicating the parasitic habits of this species and materially increased our knowledge of the pest. As might be expected, the literature produced during this brief period of time is by no means adequate. Laake *et al.* (1936) published a comparative biological study of *C. americana* and *C. macellaria* F., with detailed descriptions of the immature stages; Bruce & Sheely (1936) contributed a comprehensive account of the screwworm situation in Florida, with specific recommendations for control; and various other short papers have been published.

MATERIALS AND METHODS.—From March, 1936, to September, 1937, the writer examined and determined approximately 35,000 specimens of larvae in more than 2,500 lots secured from cases of myiasis throughout the screwworm-infested area of the United States. Each lot of specimens represented a single case, and the lots came from almost as many different localities.

The data given in the accompanying tables represent only larvae taken from wounds in living animals. They do not include wool maggots, unless there was actual evidence of an abrasion in the skin, or any specimens from carcasses and hides.

Collections were made at fairly regular intervals in the southeastern states and in

* Some of these data were presented before the Entomological Society of America at its thirty-first annual meeting in Atlantic City, N. J., December, 1936, and published in part in the *Florida Cattleman*, January 15, 1937, and also in the *Southwestern Sheep and Goat Raiser*, March 1, 1937.

Texas. In Oklahoma and California the first lots were taken late in June, 1936, and in New Mexico and Arizona late in July, 1936. From time to time sporadic outbreaks of *C. americana* were reported in states generally regarded as not being in the screwworm area. Hence, special scouting was conducted in Kansas from July to September, 1936, and in western Tennessee and eastern Arkansas in October, 1936.

In the interpretation of the data in the accompanying tables, it is necessary to consider the following limiting factors: (1) Collections were made throughout a period of 18 months. Likewise, it must be observed that in the western states, Texas excepted, operations began rather late in the season of 1936. (2) More intensive collecting was done in Florida and Texas than in other states of the infested area, and also the number of collectors operating in different states varied according to the needs for control work.

Table 1 shows the distribution of determined lots of larvae by states, and table 2 shows how these same lots were distributed according to host animals. Column 4 of each table gives the number of lots of *C. americana* that were taken in wounds together with one or more of the secondary species listed. As many as five different species of larvae have been recorded from one wound. Column 12 presents the number of cases in which two or more secondary species only were collected from one wound.

RESULTS OF IDENTIFICATIONS.—The data obtained from identifications of larvae from wounds show that *Cochliomyia americana* was responsible for 86 per cent of the infestations; the remaining 14 per cent of the infestations were distributed among various species of flies.

Of the secondary wound invaders, *Phormia regina* (Meig.), the black blowfly (also commonly called the winter blowfly, the fleece worm, the wool maggot, etc.), ranks first in importance, being responsible for 62 per cent of the infestations by secondary wound invaders, or 8 per cent of all the infestations recorded. It is the writer's opinion that it would be well not to underrate this species as a myiasis-producer, inasmuch as its activity in a wound frequently resembles that of the screwworm, *Cochliomyia americana*. Although generally conceded to be a winter species, it is interesting to note that *P. regina* was active in many of the southeastern states throughout the summer of 1936. Several lots were taken during May, June and July in South Carolina and Georgia; during May and June in Ala-

Table 1.—Species of flies involved in myiasis, as determined by identifications of larvae collected from wounds in animals throughout the screwworm-infested area of the United States—distribution by states.

States in Which Collections Were Made	Number of Infestations, by Species											Percentage Infestations, by Species			
	Total	*Cochliomyia americana*	*Cochliomyia americana* with Secondary Species	*Cochliomyia macellaria*	*Phormia regina*	*Lucilia* spp.	*Sarcophaga* spp.	*Musca domestica* L.	*Calliphora* spp.	*Syntheriomyia nudiseta* V.d.W.	Mixed Secondary Species	All Involving *Cochliomyia americana*	*Cochliomyia americana* Only	*Cochliomyia americana* with Secondary Species	Secondary Species Only
Alabama	17	2	0	0	10	2	1	0	0	0	2	11.8	11.8	0.0	88.2
Arizona	74	55	6	2	5	3	2	0	0	0	1	82.4	74.3	8.1	17.6
Arkansas	1	1	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
California	47	38	3	0	3	2	0	0	0	0	1	87.2	80.8	6.4	12.8
Florida	1,082	1,021	10	6	15	19	6	1	1	1	2	95.3	94.4	0.9	4.7
Georgia	141	116	1	1	13	8	1	1	0	0	0	83.0	82.3	0.7	17.0
Illinois*	39	37	0	0	1	1	0	0	0	0	0	94.9	94.9	0.0	5.1
Kansas	3	3	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
Louisiana*	28	21	0	1	3	2	0	0	0	0	1	75.0	75.0	0.0	25.0
Mississippi	18	0	0	0	16	2	0	0	0	0	0	0.0	0.0	0.0	100.0
Missouri*	2	2	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
New Mexico	38	30	2	0	3	0	0	0	0	0	3	84.2	78.9	5.3	15.8
Oklahoma	49	37	3	1	8	0	0	0	0	0	0	81.6	75.5	6.1	18.4
South Carolina	50	5	1	4	25	8	0	1	0	0	6	12.0	10.0	2.0	88.0
Tennessee	8	7	0	0	0	1	0	0	0	0	0	87.5	87.5	0.0	12.5
Texas	915	730	40	12	109	6	2	0	2	0	14	84.2	79.8	4.4	15.8
	2,512	*2,105*	*66*	*27*	*211*	*54*	*12*	*3*	*3*	*1*	*30*	*86.4*	*83.8*	*2.6*	*13.6*

* The collections made in Illinois and Missouri were from stockyards only, and the majority of the lots from Louisiana were also from stockyards.

bama; and in May, June and August in Mississippi.

Records of identifications suggest that no great significance need be attached to *Cochliomyia macellaria* F. as a myiasis-producer. Its name appears in most texts as that of a screwworm, but this name is now more appropriately applied to *C. americana*. *C. macellaria* is shown to be responsible for only 1 per cent of the infestations recorded. More than likely most of these cases were initiated by *C. americana*, and *C. macellaria* followed as a secondary invader. In Texas *C. macellaria* is said to be responsible for fleece worm cases during the summer months.

Of the species of *Lucilia* secured from wounds, *L. sericata* (Meig.) appeared most often. This species, which attained prominence through its use in osteomyelitis, is probably beneficial where it does not occur in excessive numbers, because its activities tend to hasten the healing of wounds.

COLLECTIONS FROM ANIMALS IN STOCKYARDS.—At the height of the fly season of 1936 the stockyards at Kansas City, East St. Louis and New Orleans were visited by scouts, and from their collections it was possible to learn of the importance of transportation of infested livestock in the distribution of *Cochliomyia americana*. The results of these observations agree with the findings of Dove & Bishopp (1936) and show definitely that there is great danger involved in the shipment of livestock from screwworm-infested areas to noninfested areas. That the 37 lots of *C. americana* secured at the National Stockyards, East St. Louis, Ill., were all from cattle shipments is a significant fact in the spread of the pest. Most of the larvae collected were mature and ready to drop from the wounds for pupation, soon to become a source of new infestations. That this inference is not without weight is verified by the fact that a calf born in October in the New Orleans Stockyards at Arabi, La., was repeatedly infested in its navel. All lots of *C. americana* taken there previously were from cattle shipped from infested areas. These data emphasize the importance of treating infested animals prior to shipment.

Table 2.—Species of flies involved in myiasis, as determined by identifications of larvae collected from wounds in animals throughout the screwworm-infested area of the United States—distribution by hosts.

Host Animals	Number of Infestations, by Species											Percentage Infestations, by Species			
	Total	*Cochliomyia americana*	*Cochliomyia americana* with Secondary Species	*Cochliomyia macellaria*	*Phormia regina*	*Lucilia* spp.	*Sarcophaga* spp.	*Musca domestica* L.	*Calliphora* spp.	*Syntheniomyia nudiseta* V.d.W.	Mixed Secondary Species	All Involving *Cochliomyia americana*	*Cochliomyia americana* Only	*Cochliomyia americana* with Secondary Species	Secondary Species Only
Cattle	1,396	1,181	19	8	159	19	0	0	0	0	10	86.0	84.6	1.4	14.0
Swine	571	515	5	6	21	16	1	1	1	1	4	91.1	90.2	0.9	8.9
Sheep	286	202	36	7	19	5	4	0	1	0	12	83.2	70.6	12.6	16.8
Goats	67	56	2	1	5	1	0	0	1	0	1	86.6	83.6	3.0	13.4
Horses	85	78	1	3	2	1	0	0	0	0	0	92.9	91.7	1.2	7.1
Mules	34	21	1	1	5	4	0	0	0	0	2	64.7	61.8	2.9	35.3
Dogs	45	41	1	0	0	0	1	1	0	0	1	93.3	91.1	2.2	6.7
Man	9	4	1	0	0	2	1	1	0	0	0	55.5	44.4	11.1	44.5
Chickens	5	0	0	0	0	5	0	0	0	0	0	0.0	0.0	0.0	100.0
Deer	2	2	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
Armadillos	2	0	0	1	0	1	0	0	0	0	0	0.0	0.0	0.0	100.0
Turtles	5	0	0	0	0	0	5	0	0	0	0	0.0	0.0	0.0	100.0
Rabbits	1	1	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
Cats	3	3	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
Coyotes	1	1	0	0	0	0	0	0	0	0	0	100.0	100.0	0.0	0.0
	2,512	*2,105*	*66*	*27*	*211*	*54*	*12*	*3*	*3*	*1*	*30*	*86.4*	*83.8*	*2.6*	*13.6*

SUMMARY.—*Cochliomyia americana* is responsible for 86 per cent of the infestations recorded.

Phormia regina is the most important of the secondary species, and is responsible for 8 per cent of the infestations recorded.

Cochliomyia macellaria is not important as a myiasis-producing species, being responsible for only 1 per cent of the infestations recorded.

There is danger of spread of *Cochliomyia americana* through shipments of infested animals.—2-18-38.

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The Fire Ant (*Solenopsis* spp.) as a Pest of Quail

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With the growing interest in wildlife conservation during the last five years has come the realization that more consideration must be given to the prevention of the serious losses among wild birds and animals inflicted by insect parasites and predators, and by the diseases carried by them. Of special interest to wildlife management in the South is the relationship of fire ants, *Solenopsis* spp., especially *geminata* (F.), to quail and other ground-nesting birds.

These ants are also important pests of agriculture, since they injure citrus trees (Clark 1931), accumulate large stores of small seeds in their mounds thus robbing wildlife of its food and farmers of their crops, damage plantings in gardens and fields, and by their bites and stings are extremely irritating to man and animals.

Under the auspices of the Cooperative Quail Study Association (H. L. Stoddard, Director) there are about one million acres of land owned and leased primarily for game in Florida, Alabama, Mississippi, Georgia and South Carolina. These estates have an estimated value of $15,000,000. There are also thousands of acres devoted to wildlife projects and game preserves not included in the above acreages. The quail on all these and on the public shooting grounds except in the northern parts of Georgia and South Carolina are subject to fire ant predation.

Detailed data concerning the actual destructiveness of fire ants to quail are available from only one area, Forshala Plantation, near Tallahassee, Fla. Stoddard with his cooperators has conducted intensive investigations of quail nests since 1924 on this plantation, and a rather clear picture of the importance of fire ants has thus been obtained by a careful study of over 2,000 quail nests from 1924 to 1937.*

DAMAGE TO QUAIL.—The greatest damage to quail by fire ants occurs during the hatching period, when the ants enter the pipped egg and consume the entire chick before it can escape from the shell. Records show that in many instances these insects have harassed the mother quail so much that she has deserted the nest. On game farms it often happens that these ants kill quail and their chicks while confined in brooder pens. There are two types of injury to quail nests. In one, all the eggs are destroyed and a renesting attempt may be made; in the other, a part of the eggs are left and the birds do not renest.

The reports of Stoddard (1931, p. 193, 1932, 1933, 1934, 1935, 1936 and 1938) show clearly the amount of damage that may be expected from these insects. Data from his reports and from his files are presented in table 1 to illustrate the magnitude of the fire ant problem.

It should be pointed out that the percentage of destruction by fire ants is actually much larger than the data in the table would indicate, since included in the total nests are those destroyed by enemies other than fire ants and those that were deserted. Such nests may total 60 to 70 per cent of all those under observation. It seems fair to disregard these when at-

* Most of the quail-nesting data since 1927 on Forshala Plantation have been secured by L. B. Campbell and C. D Hasbrouck, managers of the plantation.

tempting to arrive at an estimate of the actual ant damage, since those nests were no longer occupied at the time when the greatest ant damage occurs. Some of the deserted nests have been abandoned because of ant persecution, but it is impossible to determine the actual number of such cases.

Reports received by this bureau indicate that depredations of fire ants on quail occur in other Southern states. In California John T. Emlen, Jr., reports (1938) that *Solenopsis xyloni* McCook and *S. molesta* (Say) often invade the nests of the California quail, and on one occasion the former species was observed to destroy the young as the eggs were pipped. In Arizona, David M. Gorsuch (1934) has reported an observation on ants (species not determined) destroying the young of both the Gambel quail and scaled quail, the death of a scaled quail hen and the destruction by what appeared to be ants of brooding hens of both these species.

Table 1.—A summary of the quail-nesting data* showing the number of nests observed, and the number destroyed by fire ants on Forshala Plantation, Tallahassee, Fla., 1924–37.

YEAR	TOTAL NESTS OBSERVED	NESTS DESTROYED, ALL OR IN PART, BY FIRE ANTS
1924–27	602	24
1928	278	34
1931	195	18
1932	233	9
1933	270	22
1934	195	15
1935	297	11
1936	236	9
1937	150	9

* Data from the reports and files of H. L. Stoddard.

CONTROL METHODS AND COST.—Stoddard (1931) states: "Serious destruction by ants was encountered first during the season of 1927, when these insects were apparently more abundant than during the two preceding seasons." In order to develop some method of abating this loss, he and his associates began some tests in 1931 to determine the value of soil fumigation in destroying the ants. All fire ant colonies within a 50-foot radius of each quail nest under observation were treated with sodium cyanide (1 ounce to 1 gallon of water). In 1932, and annually since that time, these restricted treatments have been supplemented by an extensive program of applying the above solution to all colonies that could be located on the plantation. Each half of the 12,000-acre plantation has been treated in alternate years. In 1937 the colonies were treated by placing a 1-ounce egg of sodium cyanide in a hole punched about 12 inches deep into the center of the colony mound. The cost per year for these applications on the Forshala Plantation have been: 1932, $1,136.43; 1933, $607.06; 1934, $922.08; 1935, $622.70; 1936, $507.60; and 1937, $594.73.

This is the only plantation that has continued the treatments over such a long period of time, although several others have poisoned fire ants for one year. There are many thousands of acres in the fire ant area equally infested, and much of this land would be treated if an efficient method of control could be found.

In view of losses caused by fire ants and the difficulties encountered in their control on the preserves in Georgia and Florida, a project was initiated by the Bureau of Entomology and Plant Quarantine in the spring of 1935 to investigate the problem. The life history and habits of these insects and the use of soil fumigants and poisoned baits are included in the research program.

BIONOMICS.—The outstanding point concerning the biology of these insects is the fact that 7 out of 12 colonies from which the mother queen was removed in the spring of 1937 (February, March and April) are still active nearly one year later, are producing young and appear normal in all respects. All 12 colonies dwindled in size for about three months and 5 completely disappeared; the other 7 began to produce young again after a lapse of about three months. The type of ants producing the eggs is unknown, as it has seemed undesirable to disturb these colonies before the spring of 1938. It is possible that the five colonies which disappeared moved from the original site.

A thorough study of the migration of fire ants has been almost impossible, since the colonies disappear and reappear within a given area with no indication of where they have gone or whence they have come. Normal colonies have long lateral tunnels through which the ants

may migrate underground. External lines of movement are also visible following rainfall when the topsoil is moist. In an extreme case a colony was found to have moved 117½ feet. The line of travel was external in only two places, and these totaled 12 feet, so that 105½ feet of the passage was underground.

This subterranean travel makes it extremely difficult to obtain accurate data on control methods, for at the least disturbance the colony may move to a new location. The best an investigator can hope for under such conditions is a comparison of the apparent effectiveness of the various methods used. This comparison is itself difficult, for the results obtained with soil fumigants vary according to the season, the soil type and, no doubt, to a multitude of other factors.

SODIUM CYANIDE FUMIGATION.—A two-year study has been made of the efficiency of the control program on Forshala Plantation. Of 553 colonies treated in 1936 by the ant-eradication crew, 34.2 per cent showed activity three months after the application of sodium cyanide solution. The number actually destroyed is uncertain, since 70.7 per cent were still active one week following the treatments. Of these, 30.8 per cent showed scattered activity which gradually disappeared. In 1937, one week after dry sodium cyanide was applied to 100 colonies, 64.0 per cent were inactive and three months later 53.0 per cent were inactive.

In connection with the study of soil-fumigation methods two fields have been selected as eradication areas on which an attempt has been made to destroy all fire ants. One field of three acres has received 16 treatments within two years (1936 and 1937); the other, of five acres, was treated 14 times in three years (1935 to 1937). Small colonies of fire ants still persist on both plots. Observations one year after these repeated applications of cyanide show that the colonies increased in number from 61 to 139 on the three-acre area (after four treatments in 1936) and from 88 to 171 on the five-acre area (after eight treatments in 1936).† It should, however, be pointed out that the ants were drastically reduced in number. Numerical reduction of fire ants may be sufficient to relieve ant attacks on quail nests.

† This area was treated five times in 1935, but there was no record of the original number of colonies.

POISONED BAITS.—The discouraging results with the use of soil fumigants prompted a series of field experiments with poisoned baits. These experiments were conducted at various times throughout the year, but most of them during the early part of spring. The ants fed on most of the baits for a few minutes, then covered them with soil and refused to feed further. In some cases they moved away from the original colony site where the poisoned food had been applied. When dry baits were used, the ants frequently took the materials into the colony, but usually began to carry them out again within from an hour to several days.

Since no noticeable mortalities were ever obtained in the field, plaster formicaries are being used to test various bait combinations. The preliminary experiments with a number of different insecticides in the laboratory indicate that none has been sufficiently effective to take into the field for control work.

The laboratory observations in plaster cages have offered many difficulties, the most perplexing being the escape of ants from the cages. They tunneled so readily through the toweling or velvet customarily placed between the glass cover plates and the plaster forms that it was necessary to replace this material with glass strips to prevent their escape. When exit tunnels could not be made elsewhere, the ants cut into the plaster even after two coats of shellac and three of a high-grade spar varnish had been applied. The present cage is made of plaster with four coats of aluminum paint.

The importance of fire ants to wildlife is new to many of our economic entomologists; however they are only one of many insects in this field that are in need of investigation at the present time. We hope that further studies will reveal suitable means of decreasing the ravages which these pests inflict upon our wildlife resources.—5-19-38.

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Pink Bollworm Control in Southeastern States

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The pink bollworm, *Pectinophora gossypiella* (Saund.), is recognized as a major cotton pest wherever that crop is grown. It is capable of greatly increasing the cost of producing a bale of cotton should it become established. The Division of Pink Bollworm Control is concerned primarily with preventing just such an increase in the cost of cotton production to the farmer. It has three main functions: namely, inspection to determine the presence of the pink bollworm in new areas, enforcement of federal quarantines in areas placed under quarantine on account of the presence of the pink bollworm and control or eradication of the insect from areas in which it becomes established. We will briefly discuss each phase of this work, with particular reference to the southeastern states.

INSPECTION FOR THE PINK BOLLWORM.—Almost from the beginning, in 1917, of the fight to prevent the pink bollworm from becoming established in the United States, it has been necessary to carry on some inspection work in the southeastern states. One of the first reasons for such inspection work was the fact that cotton lint from infested areas in Texas was moved to textile mills in the Carolinas and Georgia, and we were under the impression that bales of lint might be a very important factor in the dissemination of the pink bollworm. Consequently, inspectors were sent to inspect cotton bolls in the fields in the vicinity of these mills.

Another reason for inspection in the southeastern states in the early '20's was an occasional movement of seed from areas subsequently found to be lightly infested with the pink bollworm. For example, a carload of seed was shipped from southwestern Louisiana to an oil mill at Shreveport, but it was diverted en route to an oil mill at Talladega, Ala. Consequently, shortly after the finding of pink bollworm infestation in southwestern Louisiana, and following the tracing of cotton products out of that area, inspectors were sent to Talladega to check up on the disposition of this carload of seed. Had it been immediately crushed, it would not have been considered of much importance. On first inquiry the oil mill management was of the opinion that all the seed had been crushed, but on further questioning it came out that a few lots had been sold for planting purposes. Consequently, it was deemed expedient to collect a large quantity of bollies for immediate inspection. Fortunately, these shipments of lint and seed did not result in the pink bollworm's becoming established in any of the southeastern states. Continued periodic inspections, however, were made throughout the period 1918 to 1931 in these states.

In June, 1932, the pink bollworm was found to be well established in the wild cotton of southern Florida. This discovery immediately changed the picture, and the domestic cotton areas in northern Florida, southern Georgia and southern Alabama came under suspicion, making it necessary to conduct intensive inspections in those areas. South Carolina and Mississippi were involved to a lesser extent, and more intensive inspections were planned than had ever been undertaken in those states.

It is well, perhaps, to mention at this point that our procedure of inspection had undergone a radical change since the early '20's. It was found that even light infestations could be readily turned up through inspection of gin trash. This gave us a point of concentration in any given area. Inspection parties were placed in each of the southeastern states. These crews were equipped with gin-trash ma-

chines, which are simply separators of the trash that has already been taken out of the seed cotton by the regular gin machinery, and are so designed that particles of the weight and size of the pink bollworm are separated from the mass of trash. This residue is then examined by hand by a trained inspector.

As a result of these gin-trash inspections light infestations of the pink bollworm were found in northern Florida in Alachua and Columbia counties in the fall of 1932. Although no pink bollworms were found in the fall of 1933 in northern Florida in the same areas in which they were found in 1932, a light infestation was discovered in a nearby county, Madison County, Fla., and three counties were involved in a light infestation in the Tifton, Ga., area. In the fall of 1934 light infestations were found in several additional northern Florida counties and a somewhat disconnected infestation was found in Jackson County, Fla., about 120 miles west of Madison. Results were negative in Georgia during the fall of 1934. Intensive inspections were again carried on in northern Florida, southern Georgia and southern Alabama during the fall of 1935, 1936 and 1937, with negative results. Consequently, following inspections in the fall of 1936 the areas in Florida were released from quarantine, as had been the case following two years of nonfindings in Georgia, which area was released following inspection in 1935.

As a matter of information we keep a record of the number of bushels of trash examined in all areas by states and counties. In an extremely dry harvesting season a bushel of trash will come from perhaps as many as ten bales of cotton. In seasons when the picking must be done under unfavorable conditions and frequent showers occur, there is more dirt in the seed cotton when it is taken to the gin and fewer bales are represented. During the period 1932 to 1937 we annually inspected trash in Alabama from 17 to 28 counties, the total amount being 33,742 bushels. The gin-trash inspections during this period in Florida covered from 8 to 15 of the cotton-growing counties, and included an aggregate of 18,348 bushels. In Georgia the smallest number of counties inspected in any one year was 42 and the maximum number 72, and a total of 50,169 bushels of trash was examined. Inspections of gin trash were conducted in South Carolina three years out of the past six, namely, 1932, 1933 and 1937, and included a total of 3,184 bushels. Gin-trash inspections were conducted in Mississippi during 1932, 1933, 1935 and 1936, with an aggregate inspection of 5,003 bushels.

We feel that the Bureau has been doing everything possible to determine the presence of an incipient infestation of the pink bollworm in the southeastern states during the past six years, and it is very encouraging that our inspections have been negative during the past three years.

FEDERAL QUARANTINE ENFORCEMENT.—We have learned in dealing with this insect that light infestations of the pink bollworm can be eradicated much more easily than heavy infestations. Conditions in northern Florida and southcentral Georgia appeared favorable for a rapid increase in the pink bollworm infestation unless control measures were quickly placed in operation. It was for this reason considered essential to place the infested areas under quarantine. The counties involved were placed under quarantine usually within a few days after the finding of the pink bollworm. This provided protection to the areas into which cotton products from these infested areas would normally have moved.

Since the early days of our fight against the pink bollworm considerable information had been gained with respect to the eradication of lightly infested areas. It was consequently deemed sufficient merely to place these areas under quarantine to prevent the movement of untreated products therefrom. The principal treatment required was sterilization of the cottonseed as a continuous process of ginning, with subsequent reheating on arrival at the oil mills in free territory. Compression of the lint was also required, so that if any seed containing a pink bollworm had entered a bale it would be crushed and the worm consequently killed indirectly by the compression. Sanitary measures around the gins were also required, such as proper trash disposal and cleaning up of the seed cotton and cottonseed so that nothing would be left around the concentration points which might harbor or carry over the pink bollworm.

There was one exception to this general

program in the southeastern states, in that through the cooperation of the Agricultural Adjustment Administration a small area around the known infested fields in Berrien County, Ga., was placed in a noncotton zone for the 1934 crop year, following a field clean-up late in the fall of 1933. Field clean-up was also carried on in the vicinity of the infested fields in Alachua and Columbia counties, Fla., in the fall of 1932. However, infestations found in other counties during the next two years were so light that we were unable to trace the infestation back to the actual farm involved.

This opportunity is taken to make acknowledgment of the splendid cooperation given the Bureau by the State Plant Board of Florida in connection with both inspection work and regulatory measures in that state, and to the office of the State Entomologist of Georgia for the active cooperation rendered in that state in both inspection work and quarantine enforcement. Alabama, Mississippi, South Carolina and the other states in the Southeast have given splendid cooperation to this Division in its inspection work in their respective states.

ERADICATION OF WILD COTTON.—In our program in the southeastern states it was evident that ultimate victory could result only through the destruction of all wild cotton plants in southern Florida. These wild cotton plants were serving as year-around hosts for the development of tremendous numbers of pink bollworms. The pink bollworm infestation in the wild cotton covered a very considerable geographical area and involved conditions very different from those in any of the other areas ever found infested with the pink bollworm in the United States. The wild cotton itself was found growing almost continuously on the keys from Miami to Key West, a distance of 175 miles. It was also found to extend from the southwestern tip of the Florida mainland, around the Florida Bay to Cape Sable, thence north along the west coast to St. Petersburg, a distance on air line of approximately 300 miles. The pink bollworm infestation in the wild cotton ranged from light infestation in the vicinity of Bradenton, Manatee County, to a 40-per cent infestation at Cape Sable and on certain of the keys lying between Miami and Key West. There is no doubt that millions of pink bollworms were hatching annually in this wild cotton.

By the spring of 1936 the average infestation in wild cotton bolls in Florida had been reduced to 1.33 per cent. This tremendous reduction was brought about despite the fact that we had not by any means completed the job of eradicating the wild cotton plants in southern Florida. Through our clean-up measures, however, we had brought about periods of nonfruiting of bolls so that no material was available in which the pink bollworm could reproduce.

You will perhaps be interested in some information with respect to the habits and characteristics of the wild cotton plant. The plants occur relatively close to the shore line, or along tidal creeks, rivers and bays. We have never found them growing naturally more than a few miles inland from the shore line. It is also fortunate that in this general area in which the wild cotton occurs the larger portion of the land is mangrove swamp or everglades, in which the plant cannot sustain itself. There are, of course, border-line situations which make it necessary for our crews to scout a tremendous area for wild cotton. We are not positive about the origin of the wild cotton in southern Florida.

Regardless of the origin of wild cotton, we found the plants possessed of many characteristics not germane to domestic cotton as we know it. For instance, we dug up and destroyed many plants with a diameter of 3 to 6 inches at the base. Still other plants assume vinelike characteristics, and runners extend along the ground for 25 to 30 feet, or perhaps may entwine themselves about buttonwood trees. One characteristic of the wild cotton plant which has made it extremely difficult to destroy is its ability to sprout from a very small root. Our inspectors consequently have to give close supervision to the digging out of the plants to see that the laborers do not break off the roots. We usually think of a cotton plant as requiring an open, sunny plot of ground in which to grow. Wild cotton plants, however, have been found in dense jungle growth, although it is true that they are usually found along the edges of the hammocks and swamps or in open glades in the jungles.

We have kept records of the number of

plants removed and the acreage from which they came. For such purposes we separate our clean-up of wild cotton plants into two general groups. One group of figures covers the original or first clean-up of the area. From June, 1932, to June, 1937, we removed a total of 1,183,593 large, mature plants and 1,001,743 seedling plants from an aggregate acreage of 12,062 acres. You realize, of course, that when we first reached them these mature plants had been producing crops of bolls for years. There have consequently fallen to the ground many bolls that have become partly or wholly covered by the soil or leaf trash on top of the ground. It is impossible to gather up all these bolls. Our efforts in digging out the cotton plants act as a cultivation of the soil, and seedlings readily come up following the original clean-up.

As we go through wild cotton areas for the first time, it is necessary to cut trails and open up the jungle to get to all plants. It is impossible, on the first going over, to locate and destroy every plant in a given area. We have consequently, in our repeated going over of the wild cotton ground, removed 41,215 mature plants, 7,688,787 seedling plants and 370,830 sprout plants which came up from the roots. In this recleaning of the wild cotton ground we list the acreage each time it is gone over. Our records at the close of June, 1937, showed we had covered the cotton ground on an average more than eight times. Naturally, some of the given locations have been recleaned more often than others, particularly those areas first cleaned during the last couple of years.

We are continually asked the question: How long will it take to eradicate the wild cotton in southern Florida? The answer to this question is dependent upon circumstances many of which are beyond our control. For instance, at the end of June, 1935, we had covered only 7,000 of the known 12,000 acreas of wild cotton ground. This means that over 5,000 acres were cleaned for the first time during the period July 1, 1935, to June 30, 1936. We are glad to report that during the fiscal year of 1936–37 only 130 acres of virgin wild cotton ground remained to be cleaned. There is still an area of a few acres of known virgin wild cotton which has not been dug out. It is located in the almost impenetrable jungle of the Everglades. These few remaining small plots of virgin wild cotton were located with an autogiro, as it was impossible for us to find them through the use of boats or trucks, or on foot. You may be surprised at the low figure of 12,000 acres of wild cotton ground. Please understand that this is a composite figure which refers only to ground actually covered by wild cotton plants. In order to clean these 12,000 acres it was necessary for our crews to cover intensively approximately 150,000 acres of ground. As an example, during the period July, 1935, to June, 1936, our crews in scouting for wild cotton covered 163,852 acres. To reclean these 12,000 acres of so-called wild cotton ground our crews will have to cover approximately 50,000 acres at each recleaning. Most of this represents tropical jungle and almost impenetrable hammocks.

In conclusion we might state that seedlings have been known to come up in areas where no wild cotton plant has been allowed to produce bolls during the previous five years. This is due to the fact that the seed of the wild cotton has an extremely hard hull and does not appear to deteriorate as does domestic cottonseed. It is believed, therefore, that a period of at least five years in which no bolls are allowed to mature will be required to complete the eradication of wild cotton. The hurricane of September 2, 1935, gave us a severe set-back in several areas. There were certain sections in the Cape Sable area and on the mainland keys in which seedlings had almost ceased to appear, but owing to the proximity of uncleaned areas this hurricane scattered bolls over the area, resulting in large numbers of seedlings reappearing following the hurricane. Other natural factors are involved, particularly the duration of the rainy season, as it is impossible for us to penetrate certain of the areas until the ground is thoroughly dried out, and if there is too long a period between recleanings the seedlings may mature bolls which drop to the ground and become covered with leaf trash.

We are able to make a very favorable report on the status of the wild cotton eradication along the upper west coast of Florida in Pinellas, Hillsborough, Manatee, Sarasota, Lee counties and to a lesser extent in Charlotte County. Final eradi-

cation is certainly within sight in that general area, as it is on most of the mainland keys between Miami and Key West. The other areas will require a somewhat longer period of time for eradication to be completed.

We consider it essential to finish the job along the upper west coast as soon as possible, owing to the rapid spread southward in Florida of the sea-island cotton plantings. Because of the excellent progress made toward final clean-up of the wild cotton plants in these upper west coast counties, we prevented the wild cotton growth and the sea-island plantings from becoming continuous. We still have a very appreciable gap of over 200 miles between these sea-island plantings and fruiting wild cotton plants.

SUMMARY.—The pink bollworm is a very destructive pest of cotton and capable of greatly increasing the cost of cotton production. The activities of the Bureau of Entomology and Plant Quarantine are discussed, with particular reference to inspection conducted in the southeastern states, to determine the presence or absence of the insect, the measures instituted to control and eradicate the pink bollworm in domestic cotton areas in northern Florida and southcentral Georgia, and the destruction of wild cotton plants in southern Florida to eliminate those plants as a breeding ground for the pink bollworm.

The inspection of domestic cotton in the southeastern states during the past three years has given negative results. Quarantine regulations have been removed from the area in which the pink bollworm was eradicated. Progress has been made toward final eradication of the wild cotton, and the clean-up measures have already resulted in substantial decrease in the degree of infestation in the wild cotton still remaining.—2-18-38.

Analysis of Data in Plat Designs for Cotton Insect Control

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The simplest methods of plat design which fulfill the conditions of supplying a valid estimate of error and eliminating a large portion of soil and insect population heterogeneity are (1) the methods of randomized blocks and (2) the Latin square. The Latin square, a randomization subject to a double restriction has been successfully used in cotton insect control experiments at several locations. In most of the experiments that have been conducted, an untreated plat was left in each row and each column, because a standard insecticide was not known, and it was desirable to compare the value of each insecticide with no treatment. The variation between the kill on the untreated plats and the kill obtained from a good insecticide may have caused the experimental error to be larger than it would have been had the check plats not been included.

The standard error measures the accuracy of an experiment and it includes errors of working, soil and infestation variations within the individual plats, size and arrangement of plats, etc. It is a useful guide to the experimenter, showing the standard of performance he is attaining in his work. During the last three years experiments using 6×6, 5×5, and 4×4 Latin squares have been conducted at this Station, at Tallulah, La., by R. C. Gaines, and at Port Lavaca, Tex., by K. P. Ewing. The standard errors for these squares in per cent of the general mean were as follows: for hopper infestation 2.1, 2.7 and 2.9; for boll weevil infestation 1.3, 1.6, 2.8, 3.8, 4.0 and 4.7; for bollworm injury 4.4, 9.4 and 2.3; and for yield 0.1, 0.8, 2.0, 3.1 and 2.8. These comparatively small estimates of error show the standard of performance attained in the cotton insect control experiments which included a check plat in each row and each column. In two of the above cases, the error in bollworm injury was affected by several treatments in the experiment which were not effective, thus causing a large variation in several groups of plats. In other words, contact insecticides used for hopper control were not

* Technical Contribution 438, Texas Agricultural Experiment Station.

effective for bollworm control. This type of comparison could be more effectively made in a factorial type of plat design. In some of the squares, the adjoining plats had as much as a 10 row buffer between them, and the plats varied in size in the different squares which in some cases tended to increase the variation and affect the error.

LATIN SQUARE.—The technique of analysis by the method of analysis of variance of the Latin square was not developed for analyzing data in experiments having check plats in the field and omitting them in the analysis of variance, but the checks can be omitted and the data analyzed, giving a valid estimate of the experimental error. These analyses are given in an effort to show the effect of having check plats in the design.

A Latin square, consisting of 16 plats, was located in the Brazos River bottoms in the vicinity of College Station, Tex., during the season of 1937. Each of the 16 plats was 12 rows wide and 69.4 feet long or one-fifteenth acre in size. Two rows were left untreated between adjoining plats.

The infestation records, number of adults and nymphs per 100 terminals, were made on the middle rows of each plat on June 14, 21 and 29 following applications which were made on June 9, 15 and 22. One pound of each insecticide was applied to each plat per application. Three insecticides: sulfur, sulfur plus Paris green (93:7), and sulfur plus calcium arsenate (90:10) were used for hopper control.

The average hopper infestation during the dusting period was used in the analysis. The analysis of variance of the Latin square containing a check plat in each row and each column is shown in table 1.

Table 1.—Analysis of variance of cotton flea hopper infestation including check plats in tests for hopper control at College Station, Tex.

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	15	990.1	
Between rows	3	8.88	2.96
Between columns	3	16.74	5.58
Between treatments	3	918.84	306.28
Remainder	6	45.64	7.61

The analysis of variance of the hopper infestation in the Latin square omitting the check plats is shown in table 2.

Table 2.—Analysis of variance of cotton flea hopper infestation omitting the check plats for hopper control at College Station, Tex.

SOURCE OF VARIATION	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	11	131.88	
Between rows	3	19.71	6.57
Between columns	3	4.17	1.39
Between treatments	2	92.16	46.08
Remainder	3	15.84	5.28

The experimental error was reduced when the data were analyzed omitting the check plats. The variance for rows or columns was not significant in either case. The only significant variance in either of the analyses was that due to treatments. The mean square may be reduced when the check plats are omitted in this type of experiment, but probably not enough to affect the comparison of the means. A comparison of the mean hopper infestation for the treatments, and the difference required for significance in the two methods of analysis are shown in table 3.

Table 3.—The mean cotton flea hopper infestation during the dusting period and the difference between two means necessary for significance with and without the check plats in tests for hopper control at College Station, Tex.

TREATMENTS	AVERAGE FLEA HOPPER INFESTATION DURING THE DUSTING PERIOD	
	Check Plats Included	Without Check Plats
Sulfur plus calcium arsenate (90:10)	11.5	11.5
Sulfur plus Paris green (93:7)	13.3	13.3
Sulfur (standard)	18.1	18.1
Check	30.9	
Significant difference	4.8	5.2

The comparisons are practically the same by either analysis. Both the sulfur plus calcium arsenate and the sulfur plus Paris green mixtures gave significantly better control than sulfur alone, at the

0.05 level. The difference required for significance was slightly increased in the analysis without the check plats, but hardly enough to affect the rating of the insecticides.

RANDOMIZED BLOCKS.—If it is desirable to have check plats in the field and omit them in the analysis of variance, the randomized block design is preferable to the Latin square. Such a layout was used in tests for cotton boll weevil control at College Station during the season of 1937. Analysis of variance of this design with and without the check plats are herein discussed.

In the randomized block design the plats were assigned at random in each block and only the degrees of freedom for treatments, blocks and error could be segregated in the analysis. The layout used contained four blocks, each with five plats. Each plat was six rows wide and 90 feet long or one-twenty-fourth of an acre in size. A buffer of two rows was left untreated between adjoining plats. A check or untreated plat was left in each block and each of the following: Calcium arsenate (A), calcium arsenate (B), calcium arsenate (C), and calcium arsenate plus sulfur plus Paris green mixture was applied to a plat in each block at the rate of about 8.5 pounds per acre per application. Applications were made on July 20, 24 and 29. An average of the boll weevil infestation records taken on July 24, 28 and August 2 and 7 was used in the following analyses of variance. In the analyses shown in table 4, the check plats were considered as a treatment and were omitted to show their effect on the experimental error.

Table 4.—Analyses of variance of boll weevil infestation in tests at College Station, Tex.

Source of Variation	Degrees of Freedom		Sum of Squares		Mean Square	
	With Check Plats	Without Check Plats	With Check Plats	Without Check Plats	With Check Plats	Without Check Plats
Total	19	15	1277.0	372.4		
Between blocks	3	3	49.0	35.2	16.3	11.7
Between treatments	4	3	1186.0	308.2	296.5	102.7
Remainder	12	9	42.0	29.1	3.5	3.2

Table 5.—The mean percentage of punctured squares for the treatments during the dusting period and the difference between two means necessary for significance with and without the check plats in tests at College Station, Tex.

Treatments	Per Cent Punctured Squares	
	With Check Plats	Without Check Plats
Calcium arsenate (A)	10.0	10.0
Calcium arsenate (B)	10.7	10.7
Calcium arsenate (C)	11.2	11.2
Calcium arsenate plus sulfur plus Paris green mixture	20.7	20.7
Check	29.8	
Significant difference	2.9	2.8

It will be noticed that the experimental error was only slightly reduced by omitting the check plats in the analysis of variance. In this case the check plats had very little effect on the error. The only significant variance was that due to treatments. The variance for treatments was of course reduced when the check plats were omitted, but was highly significant in either case.

A comparison of the average boll weevil infestation for the various treatments and the difference necessary for significance with and without the check plats are shown in table 5.

The results are practically the same regardless of whether the check plats are included or not. There was no significant difference between the control obtained from the three calcium arsenates, but they all gave a significantly better control than the mixture.

FACTORIAL DESIGN.—Factorial experiments include all combinations of several sets of treatments, and some of these simpler types of design with appropriate methods of analysis can be effectively used in cotton insect control experiments.

For example, entomologists in this state are concerned with evaluating the results of a seasonal insect control program. Two experiments of this type were begun during the 1937 season at this Station, but due to the low infestations of bollworms and weevils they could not be completed. However, all was not lost because comparisons between the treatments for hopper control and no treatment could be made. The arrangement of the plats in one of the experiments was as follows:

G A J I C E B K H D L F
C D I A G H K E J L F B
B H E J D A G L C F I K

Plats A, B, C received no treatment, plats D, E, F, G, H, I received treatments of sulfur in June for hopper control, plats G and J were to receive arsenical A, plats H and K arsenical B, and plats I and L arsenical C in July and August. The analysis of a complete experiment of this type would give comparisons between no treatment, sulfur for hopper control, arsenicals A, B and C for bollworm and weevil control, and hopper control followed by bollworm and weevil control obtained from the three arsenicals. Thus in one layout information can be obtained on the responses to all the different treatments as well as the combination where heretofore this information has been obtained in different experiments with less precision than that of the factorial design.

SUMMARY.—The estimate of errors shows the precision of the Latin square experiments with a check considered as a treatment. The analysis of variance indicates that the estimated experimental error was slightly higher in the analysis of the data containing check plats than when the same data were analyzed omitting the check plats. This higher error, however, did not affect the rating of the insecticides. In cases where it is desirable to have check plats in the field for comparison of the value of all insecticides used, and yet obtain the smallest possible error affording close comparisons among the insecticides, the randomized block design with ample replications will be preferable. Since the check plats had little affect on the experimental error, until the number of experiments conducted has reached a point, whereby one can be certain of the value of a standard insecticide, it will probably be desirable to include checks in plat designs for comparisons with the standard as well as with the other insecticides in the test.

In experiments where it is desired to compare treatments and combinations of treatments, the factorial design is preferable.—2-18-38.

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Toxicity of Ten Arsenical Poisons to Fifth Instar Cotton Leaf Worms*

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The Campbell & Filmer (1929) sandwich method for determining median lethal doses of stomach poisons, as modified by Hansberry & Richardson (1937), has been used, with a few slight changes, for determining the toxicity of several arsenical insecticides to fifth instar cotton leaf worms, *Alabama argillacea* (Hbn.). The original Campbell & Filmer method was not satisfactory with this species because the larvae would usually feed on only one leaf and not eat through the sandwich. The materials tested were calcium arsenate, lead arsenate, Paris green and mixtures of Paris green and calcium arsenate.

METHODS.—Cotton leaf squares, which measured exactly 10 millimeters square, together with a rectangular piece of paper exactly 20 times as large, were dusted under a large celluloid bell jar by the air-float method. The piece of paper was weighed before and after dusting and from these weights the quantity of dust on a leaf square was calculated. The dusted

* L. O. Ellisor, of the Louisiana Agricultural Experiment Station, Baton Rouge, La., furnished valuable suggestions on methods in this study.

leaf squares were placed on moist sand in a flowerpot saucer with the dusted surface downward. One larva was then confined over each square by means of a celluloid cup approximately 1½ inches in diameter and 2 inches high. The larvae that were observed to disturb the poison on the leaf squares were discarded.

Individual doses were varied by taking the poisoned leaf squares from the larvae after they had consumed approximately the desired amount. With practice the dosage could be controlled satisfactorily by varying the amount of poison deposited on the leaf squares and the amount of leaf area consumed by the larva. After feeding on the poisoned leaf square each larva was given a section of fresh unpoisoned cotton leaf and was fed daily for 96 hours to determine if it died or recovered.

After the caterpillars had fed, the partly eaten leaf squares were superimposed on millimeter cross-section paper and examined under a binocular microscope to determine the area consumed. From the area of leaf consumed, on which there was a known quantity of poison, and the weight of the larva, the number of milligrams of poison consumed per gram of body weight was computed. Larvae were weighed on an analytical balance to the nearest milligram.

In order to have a fairly high percentage of the larvae feed within a reasonable length of time it was necessary to weigh them during the afternoon and confine them in the celluloid cups without food until the following morning, at which time they were offered poisoned leaf squares. By doing this, from 60 to 90 per cent of the larvae would feed within a reasonable length of time.

Checks, or larvae that were not permitted to feed on poisoned leaf squares, were included, and it was found that a very small percentage died within four days. Parasitized larvae were discarded as soon as this condition was noticed. Field collected larvae were used in all tests.

To determine the median lethal dose for each poison, the data were plotted, according to the method of Bliss (1935), with the ordinates as probits of percentage mortality and the abscissas as logarithms of milligrams per gram of body weight. Each regression line was fitted by eye to the points representing the experimental data, and the dosage required to kill 50 per cent of the population was read from the graphs.†

Table 1.—Summary of data obtained on the toxicity of 10 stomach poisons to fifth-instar cotton leaf worms.

Poison	Sublethal Zone		Intermediate Zone			Lethal Zone	
	Dosage Range, Mg. per G.	Larvae Recovered, Number	Dosage Range, Mg. per G.	Larvae Recovered, Number	Larvae Died, Number	Dosage Range, Mg. per G.	Larvae Died, Number
Paris green (I.D. 3673)	0.001–0.004	5	0.01–0.03	8	14	0.04–0.67	47
Calcium arsenate (I.D. 3672)	0.010–0.060	19	0.07–0.46	116	70	0.47–1.35	19
Paris green (I.D. 3673) and calcium arsenate (I.D. 3672):							
I.D. 3678, 10:90	0.020	6	0.03–0.08	13	17	0.09–0.34	24
I.D. 3738, 7.5:92.5	0.020–0.040	6	0.05–0.15	27	18	0.16–0.22	11
Calcium arsenate:							
I.D. 3671	0.010–0.080	32	0.09–0.21	34	18	0.23–0.52	19
I.D. 3737	0.010–0.060	7	0.07–0.22	38	17	0.23–0.47	16
I.D. 3174	0.010–0.060	8	0.07–0.15	19	22	0.16–0.72	30
I.D. 3208	0.040–0.070	5	0.08–0.20	24	14	0.21–0.41	25
I.D. 3209	0.030–0.500	33	0.51–1.00	37	31	1.05–1.24	8
Lead arsenate (I.D. 3674)	0.004–0.008	5	0.01–0.03	11	9	0.04–0.38	53

Results.—Table 1 gives the dosage range in the sublethal, intermediate and lethal zones as defined by Campbell & Filmer (1929) for each of the 10 poisons, and the number of larvae used in each zone. Table 2 gives the chemical analysis

† The author acknowledges with thanks the assistance given by J. C. Gaines of the Texas Agricultural Experiment Station in determining the median lethal doses from the data.

of each poison,‡ the median lethal dose (M.L.D.) and the relative toxicity as compared with calcium arsenate 3672 as a standard.

A mixture of this calcium arsenate and 7.5 per cent of Paris green was 2.8 times as toxic as the calcium arsenate, whereas when 10 per cent of Paris green was added to this calcium arsenate the mixture was 6.3 times as toxic as the calcium arsenate alone. Paris green alone was 25 times as toxic as calcium arsenate 3672.

Of the five additional calcium arsenates materials. Calcium arsenate 3208 was 4.0 times as toxic as 3209, and 3174 was 6.0 times as toxic as 3209. These figures indicate a rather high correlation between the median lethal dose and the particle size of the samples, the coarsest material being the most toxic.

Smith, Scales & Gaines (1938) found in cage tests that calcium arsenate 3174 was the most effective of 20 samples of calcium arsenate. Sample 3208 fell in the intermediate zone and sample 3209 was least effective. The average net mortali-

Table 2.—Median lethal doses of 10 stomach poisons for fifth-instar cotton leaf worms.

Poison	Total As_2O_3 Per Cent	Water-Soluble As_2O_3, Per Cent	Total As_2O_5, Per Cent	Water-Soluble As_2O_5		M.L.D. Mg. per G.	Relative Toxicity Referred to Calcium Arsenate I.D. 3672
				A.O.A.C. Method, Per Cent	N.Y. Method, Per Cent		
Paris green (I.D. 3673)	58.4	2.33				0.01	25.0
Calcium arsenate (I.D. 3672)			43.50	0.11	0.40	0.25	1.0
Paris green (I.D. 3673) and calcium arsenate (I.D. 3672):							
I.D. 3678, 10:90		0.38	45.40	0.10		0.04	6.3
I.D. 3738, 7.5:92.5	5.06		44.72	0.03		0.09	2.8
Calcium arsenate:							
I.D. 3671			40.50	0.14	0.37	0.18	1.4
I.D. 3737			42.10	0.03	0.86	0.19	1.3
I.D. 3174			43.57	0.18	11.5	0.12	2.1
I.D. 3208			41.00	0.11	6.0	0.18	1.4
I.D. 3209			43.14	0.11	0.6	0.72	0.3
Lead arsenate (I.D. 3674)			31.10	0.22		0.02	12.5

tested, four are recommended for boll weevil control, while the fifth, 3209, was a special calcium arsenate. It will be seen that there was considerable variation in the toxicity of these calcium arsenates. Calcium arsenate 3671 was 1.4 times; 3737, 1.3 times; 3174, 2.1 times; 3208, 1.4 times; and 3209, only 0.3 times as toxic as the standard 3672. Lead arsenate was found to be half as toxic as Paris green and 12.5 times as toxic as calcium arsenate 3672.

Calcium arsenates 3174, 3208, and 3209 were selected because of their known physical and chemical properties. According to Goodhue (1937), sample 3174 (B) was one of the coarsest materials, sample 3208 (L) fell in the medium group and sample 3209 (M) was one of the finest

‡ The chemical analyses were furnished by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

ties of boll weevils for these three samples were 85, 64 and 27 per cent, respectively. These figures are of the same order as the relative toxicities according to the median lethal doses of these samples. To show further the relation of median lethal doses of these six calcium arsenates to particle size, photomicrographs are presented in fig. 1.

So far as is known, cotton leaf worms have not been hitherto used to determine the median lethal doses of stomach poisons. It is possible, however, to make a few comparisons of relative toxicity with published data where other lepidopterous larvae were used. Hansberry & Richardson (1936) reported median lethal doses of 0.09 milligram for lead arsenate and 0.04 milligram of Paris green for the imported cabbage worm, *Pieris rapae* (L.). The Paris green was thus 2.25 times as toxic as lead arsenate, whereas in the work reported herein it was 2.0 times as

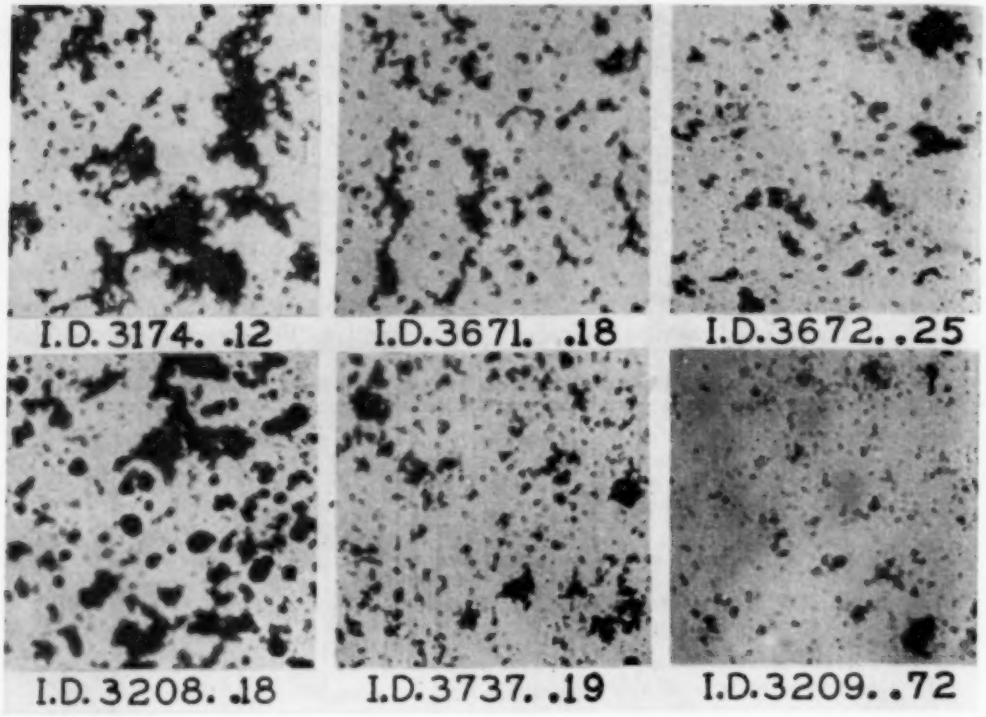

FIG. 1.—Photomicrographs of the six calcium arsenates used. ×100. The M.L.D. for fifth instar cotton leaf worms is given at the right of each I. D. number.

toxic. Hansberry & Richardson (1936) also reported for fourth-instar silkworms, *Bombyx mori* L., a median lethal dose of 0.09 milligram for lead arsenate and of more than 0.78 and 0.26 milligram for two samples of calcium arsenate, which makes lead arsenate approximately 9.0 and 3.0 times, respectively, as toxic as the calcium arsenates. In unpublished records Ellisor reported a median lethal dose of 0.10 milligram of lead arsenate for the imported cabbage worm and 0.74 and .53 milligram of two calcium arsenates, which makes the lead arsenate approximately 7.0 and 5.0 times, respectively, as toxic as the calcium arsenates. In the tests reported herein the toxicity of lead arsenate ranged from 6.0 to 36.0 times that of the six calcium arsenates. Since there was much variation in the toxicity of different brands of calcium arsenate, it is not possible to make accurate comparisons. In both the writer's investigations and those of others, however, where lepidopterous larvae were used, lead arsenate was from several to many times as toxic as the calcium arsenate.

SUMMARY.—The median lethal doses of six calcium arsenates, lead arsenate, Paris green and two mixtures of Paris green and calcium arsenate were determined for fifth-instar cotton leaf worms. The median lethal doses for the calcium arsenates range from 0.12 to 0.72 milligram per gram of body weight; for a mixture of 7.5 per cent Paris green and 92.5 per cent calcium arsenate, 0.09 milligram; for a mixture of 10 per cent Paris green and 90 per cent calcium arsenate, 0.04 milligram; for lead arsenate, 0.02 milligram; and for Paris green, 0.01 milligram.—2-25-38.

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The Cotton Aphid in Relation to the Pilosity of Cotton Leaves

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Some varieties of cotton are very pilose while others are almost glabrous. During the season of 1937 the experiments used for other investigations provided an opportunity to secure information on the cotton aphid, *Aphis gossypii* Glov., in relation to the pilosity of cotton leaves.

Previous investigations (Dunnam 1936) have shown that the more pilose cottons retained more calcium arsenate dust and retained it over a longer period than the almost glabrous cottons. This fact suggested that applications of poison might upset the agents of natural control and cause the population of aphids to increase at a more rapid rate among the pilose cottons, since Folsom & Bondy (1930) pointed out that excessive applications of calcium arsenate destroyed the parasites which held the aphid populations in check, occasionally resulting in outbreaks of this pest.

METHODS USED.—Varieties of cotton with different degrees of pilosity were selected within a block of 78 rows, each 120 feet long, in which the plants were thinned to one stalk to the hill, each hill 12 inches apart in the drill. Some varieties appeared in single rows, some were replicated twice and others were replicated three times. The major part of the block was not dusted, but a few rows were treated, some with three and some with seven applications of calcium arsenate dust.

The first test represented three replicate plantings of a glabrous and of a very pilose variety, in which one replication was dusted three times, one was dusted seven times and the other was not dusted. The two varieties were grown in adjacent alternate rows where dust was applied, but the undusted rows were separated by 11 rows and located some distance away. It would appear that in the dusted rows this arrangement might tend to equalize the aphid population because of the interlocking of branches, but no information was secured to substantiate this possibility. In the second test, varieties with intermediate pilosity were grown in two replications at some distance from each other. One replication was dusted seven times and the other left as a control. The undusted rows were four or more rows apart and the dusted rows were separated by one row in each case. In the third test, two selections of crosses of the same parentage were compared in order to eliminate the varietal factor, or possible preference by aphids which might be due to either leaf type or composition of the parenchyma. One of the selections was glabrous and one was intermediate in pilosity; neither was dusted.

On October 11, three weeks after the last poison application, when the season was well advanced and the plants had matured, one $2\frac{1}{2}$-inch disk was cut from the fourth leaf from the top of 100 of the plants on each row by means of a leaf cutter. The total area of the 100 disk samples taken from each variety was 490.87 square inches. Actual counts of the aphids on the lower surface of the disks were made by the use of a binocular. The pilosity was determined by counting the hairs of 2,375 square millimeters of the lower leaf surface by means of a binocular microscope. These samples were taken from the same leaf zone of the plants as were the disks.

RESULTS.—Data obtained on the aphid population and parasitization on cotton when not dusted and when dusted three and seven times are shown in table 1.

In test 1 the undusted pilose cotton, as

compared with the almost glabrous cotton, had 5.8 times the number of live aphids and 11.7 times the number of hairs on the lower leaf surface. Where three applications of poison had been made on each, the number of live aphids on the pilose cotton had dropped to 3.5 times, but after seven applications of poison this figure had but slightly changed to 3.7 times as many aphids. When each control, the same general trends were maintained. On the undusted moderately pilose cotton the average number of live aphids was 3.1 times that on the less pilose, while the average number of hairs was only 1.9 times that on the less pilose.

After seven applications of dust had been applied on the two types in test 2 there was a significant increase in the live aphid population on each group, but

Table 1.—Comparison of aphid populations, percentage of parasitization and leaves infested on glabrous, intermediate and pilose varieties of cottons given different treatments. Stoneville, Miss., 1937.

Types	Average Number Hairs per Square Millimeter	Times Dusted	Number of Aphids		Per Cent	
			Alive	Dead Parasitized	Aphids Parasitized	Leaves Infested
			Test 1			
Glabrous	0.52	0	16	6	27.27	17
Glabrous	0.52	3	109	127	53.81	53
Glabrous	0.52	7	276	168	37.84	40
Pilose	6.09	0	93	11	10.58	41
Pilose	6.09	3	380	122	24.30	80
Pilose	6.09	7	1,008	314	23.75	93
			*Test 2**			
Intermediate	2.34	0	22.0	10.5	32.31	13
Intermediate	2.34	7	145.0	84.0	36.68	54
Intermediate	4.48	0	69.0	11.5	14.29	33
Intermediate	4.48	7	219.5	93.0	29.76	58
			Test 3			
Glabrous	0.41	0	25	19	43.18	15
Intermediate	3.79	0	110	26	19.12	40

* Test 2 is an average of duplicate experiments.

variety is considered separately it is shown that where three applications of poison were applied to the more pilose type the population was increased to 4.1 times that of the control, but where it was dusted 7 times it was increased to 10.8 times. Under the same conditions the aphid populations of the glabrous type were increased to 6.8 and 17.0 times, respectively. While the total live aphid population was greater on the pilose cotton under all conditions, the corresponding percentages of parasitization were less. Where seven applications of poison had been applied to each type the number of parasitized aphids had increased to approximately 28 times that of the respective controls.

In test 2, on two intermediate pilose types of cotton, in which one replication was dusted and the other was left as a the difference between the two had decreased to only 1.5 times. It is thus seen, in both tests, that when the margin between pilosity decreased in these cottons, the margin between aphid populations decreased in both dusted and undusted cotton. When each type in this test is considered separately it is shown that where seven applications of poison were applied to the more pilose types, the aphid population was increased to 3.2 times that of the control, but where the more glabrous type received the same treatment the corresponding population was increased to 6.6 times. The percentage of parasitized forms was also less in the more pilose cottons, although where seven applications of poison had been applied to each type the number of parasitized aphids increased in each type approximately 8 times.

On the crosses used in test 3, where no dust had been applied at any time during the season, there were 4.4 times as many live aphids and 9.2 times as many hairs on the intermediate pilose selection as on the glabrous. Again the percentage of parasitized aphids was greater on the glabrous selections.

Fig. 1 represents a parabolic curve of the second order (Love 1936) fitted to the data in which the live aphid populations on all undusted cottons in the three tests are plotted against the average number of hairs per square millimeter. There was practically no change in such a curve when the live and parasitized aphid populations were used in such calculations.

DISCUSSION.—The percentage of leaves infested on each type of cotton, as shown by leaf-disk samples, varied somewhat in direct proportion to the aphid population. In each test the aphid population found on undusted cotton was in direct proportion to the number of hairs per square millimeter on the lower leaf surface, where this insect was breeding. But in the tests where calcium arsenate had been applied the population on the glabrous cottons was increased at a greater ratio than on the more pilose, when compared with the control. An analysis of the combined data from undusted plots in all tests showed no significant correlation between the number of aphids parasitized and the average number of hairs per square millimeter on the lower leaf surface. In one test with a great difference in pilosity, where seven applications of calcium arsenate had been applied, the number of parasitized forms was 28 times as great on the glabrous and 28.5 times as great on the pilose cotton as on the respective controls, and in another test with less difference in pilosity, where seven applications of calcium arsenate had been applied, the number of parasitized forms had increased to 8 times the number on the controls. The above analysis indicates that the parasites were more or less equally distributed among all the cottons, and naturally the percentage of parasitization would be greater in the lighter populations on the more glabrous types.

Thus it is shown that, where calcium arsenate was applied and the aphid population was increased, the rate of parasitization in the two types in each test was not significantly changed. Therefore these data do not explain the differences in the ratio of increase in aphid population when the cottons were dusted. Had records been made of the parasitization from the time that the dusting was started, more light might have been thrown upon this point. If the effect of the poison upon the parasites was of short

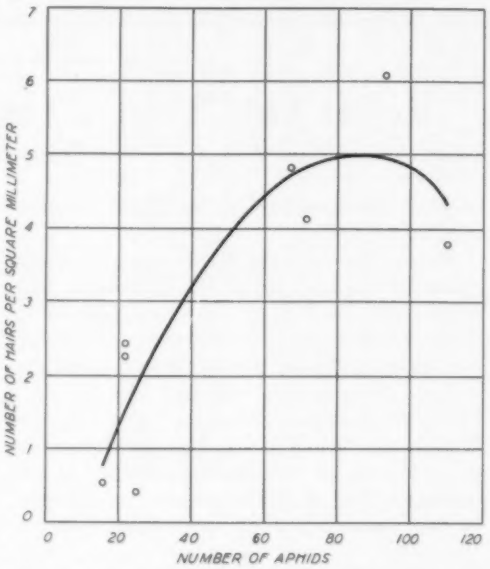

FIG. 1.—Parabolic curve showing the live aphid population per sample of 100 disks from undusted cotton leaves in relation to the number of hairs per square millimeter of lower leaf surface.

duration, records made three weeks after the poisoning was completed might not be reliable. Field observations showed that the aphid populations were much greater on all cottons immediately after the poisoning was completed than when the records were made. Furthermore, no information is at hand as to the length of time that the parasitized forms remain attached to the leaves.

SUMMARY.—In tests conducted at Stoneville, Miss., during 1937 with cottons of different degrees of pilosity, the aphid population increased in direct proportion to the number of hairs on the lower leaf surfaces. There was a significant increase in aphid population on all types of cotton following three or seven applications of calcium arsenate dust, but the ratio of increase was greater on the glabrous varieties. No correlation was found between the numbers of parasitized aphids and the pilosity of leaves, although

the percentage of parasitization was greater on the glabrous types of cotton with the smaller aphid populations. The data presented do not explain the differences in the ratio of aphid increases on dusted cotton.—2-18-38.

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Recent Field Tests of Insecticides for Control of the Cotton Bollworm

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From 1928 to 1930 field tests of insecticides for the control of the bollworm, *Heliothis obsoleta* (F.), were conducted in Texas by Moreland & Bibby (1931). The insecticides included were calcium arsenate, sodium fluosilicate, calcium arsenate + 2 per cent nicotine, and calcium arsenate plus 25 per cent Paris green. Calcium arsenate gave the most profitable returns of the materials tested. In later tests using small plots Gaines (1937) found that calcium arsenate, calcium arsenate plus sulfur 50:50, and calcium arsenate plus Paris green 95:5 applied at the rate of about 8.5 pounds of calcium arsenate per acre were equally effective in controlling bollworms, but when calcium arsenate was mixed with 25 per cent of lime, thus reducing the poundage of calcium arsenate per acre, the control was decreased.

During the seasons of 1936 and 1937 the second generation of bollworms caused considerable injury to young cotton in eastern Texas, affording an excellent opportunity for further field tests on the control of this pest. The following insecticides were used: calcium arsenate; calcium arsenate plus Paris green mixtures; and various proportions of derris, pyrethrum, calcium arsenate, barium fluosilicate and cryolite mixed with sulfur. In all mixtures the amount of calcium arsenate applied was at least 25 per cent less then when this material was used alone.

LOCATION AND SIZE OF EXPERIMENTAL PLOTS.—Nine experiments were conducted in Burleson County, Tex., five in 1936 on cotton planted in May and four in 1937 on cotton planted in June. Each experiment consisted of four plots of the same size, but ranging, in the different experiments, from 0.44 to 1.00 acre and averaging 0.63 acre. All the plots in one experiment were located where they would be comparable. Three of the plots were treated with one of the insecticides mentioned above, and the fourth was left untreated as a check. To avoid drifting of the insecticides into the checks, the untreated plots were always located on the side of the prevailing wind.

DUSTING APPLICATIONS.—In 1936 dusting was begun on August 13 and continued until September 5, and from two to five effective applications were made in each plot. In 1937 dusting was begun on August 3 and continued until August 13, and each treated plot received three effective applications. Most of the dusting was done between 5 and 7 a.m. while the cotton was wet with dew and there was little or no breeze. In 1936 one application had to be repeated in two experiments, as it was washed off by rain within 24 hours. In 1937 no rain fell on any of the plots from June 6 to October 16.

Hand dusting machines were used in applying the insecticides. Effective control depends largely on a thorough distribution of the insecticide, at the proper time, to that portion of the plant attractive to the bollworms in the early stages. Therefore, the nozzle of the guns was held immediately over the top or more succulent portion of the plants to give a thorough coverage to the outer portions.

* In cooperation with the Texas Agricultural Experiment Station, College Station. Thanks are due A. B. Beavers for assisting in obtaining the field notes.

Table 1.—Bollworm control experiments at College Station, Tex., 1936.

Experiment	Period of Treatment	Insecticide	Number of Effective Applications	Pounds of Insecticide per Application per Acre	Average Per Cent Infestation for Dusting Period	Yield of Seed Cotton Pounds per Acre	Gain per Acre in Treated Over Untreated Plot		Net Profit per Acre from Dusting
							Pounds	Per Cent	
1	Aug. 13 to Aug. 29	Calcium arsenate	4	9.0	8.9	1042	606	138.9	$22.51
	Aug. 13 to Aug. 19	Calcium arsenate	2	8.6	10.5	899	463	106.2	18.02
	Aug. 13 to Aug. 24	Calcium arsenate	3	8.5	8.9	889	453	103.9	16.92
		Check, no treatment	—	—	18.7	436	—	—	—
2	Aug. 13 to Aug. 29	Calcium arsenate	4	9.2	8.7	1063	542	104.0	19.75
	Aug. 13 to Aug. 20	Calcium arsenate	3	9.8	7.7	930	409	78.5	14.72
	Aug. 13 to Aug. 22	Calcium arsenate	3	9.1	8.3	921	400	76.8	14.47
		Check, no treatment	—	—	22.3	521	—	—	—
3	Aug. 13 to Sept. 5	Calcium arsenate	5	7.8	9.4	1090	611	127.5	21.44
	Aug. 13 to Sept. 5	Calcium arsenate 95, Paris green 5	5	8.7	8.9	969	490	102.2	15.68
	Aug. 13 to Sept. 5	Calcium arsenate 90, Paris green 10	5	7.9	9.4	957	478	99.8	15.09
		Check, no treatment	—	—	21.3	479	—	—	—
4	Aug. 15 to Sept. 1	Calcium arsenate	4	6.0	4.3	673	248	58.1	7.96
	Aug. 15 to Sept. 1	Calcium arsenate 50, sulfur 50	4	7.4	2.5	653	226	52.9	7.36
	Aug. 15 to Sept. 1	Sulfur 90, pyrethrum 10	4	7.4	6.8	451	24	5.6	−1.77
		Check, no treatment	—	—	10.0	427	—	—	—
5	Aug. 15 to Sept. 4	Calcium arsenate	4	7.9	6.3	673	288	74.8	8.51
	Aug. 15 to Sept. 4	Calcium arsenate 80, cubé 20	4	7.4	5.6	635	250	64.9	2.57
	Aug. 15 to Sept. 4	Calcium arsenate 90, Paris green 10	4	7.5	5.5	680	295	76.6	8.21
		Check, no treatment	—	—	19.3	385	—	—	—

The data for these applications are summarized in tables 1 and 2. The average quantity of calcium arsenate used per acre application in the 15 plots treated with calcium arsenate was 8.54 pounds, the minimum being 6.0 in experiment 4 and the maximum 9.8 in experiment 2. The calcium arsenate plus Paris green mixtures ranged from 7.5 pounds in experiment 5 to 9.0 pounds in experiment 2A, with an average of 8.2 pounds. The calcium arsenate plus sulfur mixtures ranged from 7.4 pounds in experiment 4 to 13.4 pounds in experiment 1A, with an average of 10.5 pounds per acre. The quantities of the other mixtures ranged from 7.4 to 14.9 pounds per acre.

In addition to the application for bollworm control, in September, 1936, one application was made on each of the checks for control of the cotton leaf worm, *Alabama argillacea* (Hbn.). In 1937 an application of 3.5 per cent nicotine plus lime dust was made on August 6 to each of the four experiments for the control of

Table 2.—Bollworm control experiments at College Station, Tex., 1937.*

Experiment	Insecticide	Pounds of Insecticide per Application per Acre	Average Per Cent Infestation for Dusting Period	Yield of Seed Cotton Pounds per Acre	Gain per Acre in Treated Over Untreated Plot		Net Profit per Acre from Dusting
					Pounds	Per Cent	
1A	Calcium arsenate	9.2	37.8	414	409	8180.0	$15.03
	Calcium arsenate 50, sulfur 50	10.8	43.2	160	155	3100.0	4.22
	Calcium arsenate 33⅓, sulfur 66⅔	13.4	42.9	207	202	4040.0	6.18
	Check, no treatment	—	69.0	5	—	—	—
2A	Calcium arsenate	7.0	24.4	506	316	166.3	11.33
	Calcium arsenate 92½, Paris green 7½	7.7	35.8	506	316	166.3	10.87
	Calcium arsenate 90, Paris green 10	9.0	41.1	477	287	151.0	9.10
	Check, no treatment	—	52.8	190	—	—	—
3A	Calcium arsenate	8.8	29.8	559	370	195.8	13.20
	Calcium arsenate	9.3	25.4	546	357	188.9	12.62
	Calcium arsenate	8.9	25.7	599	410	216.9	14.88
	Check, no treatment	—	55.8	189	—	—	—
4A	Calcium arsenate	9.1	32.2	558	209	59.9	6.03
	Cryolite 20, sulfur 80	14.9	54.0	237	−112	−32.0	−7.84
	Barium fluosilicate	10.8	20.4	687	338	96.8	11.71
	Check, no treatment	—	40.3	349	—	—	—

* The period of treatment in all experiments was from August 3 to 13, and there were three effective applications in each plot.

the cotton aphids. This application controlled the aphids and no further treatment was necessary for this pest. As no control measures were being used in the surrounding fields, cotton was rapidly being defoliated by leaf worms, causing boll weevils as well as leaf-worm moths to migrate to the cotton in the experimental plots. Therefore, two applications of calcium arsenate were necessary later in the 1937 season to protect the late developing bolls from these pests. Many of the small bolls were later thrown off owing to the prolonged drought.

INFESTATION.—At the time the experimental plots were selected, a sufficient number of plants was examined for eggs, worms and injury to show that the infestation was uniform. The first infestation records considered in this report were made several days after the first application of insecticide. These records were obtained by examining all squares and bolls on 30 cotton plants in each plot, 10 plants near the center and 10 near each end, for bollworm injury. Records were taken at approximately seven-day intervals throughout the season.

During 1936 bollworm injury was greater in experiments 1, 2 and 3 than in experiments 4 and 5. This is attributed largely to the condition of the plants in the two fields. The cotton in experiments 1, 2 and 3 was on land that had been planted to alfalfa in 1935, and the plants were more succulent and developed into larger plants, giving greater yields than those in experiments 4 and 5, where the land had been planted to cotton the previous year. In 1937 all four experiments were located in the same field, which gives good yields under favorable conditions. The bollworm infestation was somewhat higher in the northern portion of the field where the plots of experiment 1A were located than it was where the other experimental plots were located in the southern portion. In both years the July generation of bollworms had injured practically all the fruit on the plants in all the experimental plots. The plants continued to fruit, however, and when the August generation appeared dust applications were begun. The bollworm infestation continued to rise in the check plot of each experiment from the time dusting was begun until the peak was reached, but a sharp decrease was noticed in the plots treated with effective insecticides.

GAIN FROM DUSTING.—The production of seed cotton from about half of each plot was recorded at each picking. Tables 1 and 2 show this production on an acre basis. In 1936 gains from the five plots treated with four and five effective applications of calcium arsenate ranged from 248 to 611 pounds per acre, averaging 459 pounds and a profit of $16.03. In some experiments the bollworm infestation was light, while in others the infestation was heavy. In four other plots receiving two and three applications of calcium arsenate at intervals of two, three and four days in the heavily infested cotton, the gain ranged from 400 to 463 pounds per acre, with an average of 431 pounds. In 1937 the average gain for the four plots receiving three applications of calcium arsenate was 326 pounds, netting an average profit of $11.39 per acre. The average during the two seasons in the plots treated with calcium arsenate plus Paris green mixtures was 373 pounds, with a profit of $11.79. In the plots treated with calcium arsenate plus sulfur mixtures the gains were less than in the calcium arsenate treated plots owing to the reduction in poundage of calcium arsenate per acre. In experiment 1A, where the calcium arsenate was reduced to 5.4 and 4.5 pounds by adding sulfur, as compared with 9.2 pounds of calcium arsenate alone, the net profit was likewise reduced to less than one-half.

In experiment 4A three applications of barium fluosilicate netted a profit of $11.71 as compared with only $6.03 on the calcium arsenate treated plot. This is based on only one experiment, and the profit from barium fluosilicate was not so great as the average profit of $13.74 obtained from calcium arsenate.—2-18-38.

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Sulfur and Calcium Arsenate for the Control of the Cotton Flea Hopper and the Boll Weevil

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The standard insecticide for control of the boll weevil, *Anthonomus grandis* Boh., is calcium arsenate and that for the cotton flea hopper, *Psallus seriatus* (Reut.), is sulfur. These insecticides are usually applied separately for each insect. Occasionally heavy infestations of both insects occur simultaneously in a field of cotton, and frequently a heavy infestation of one of these insects occurs along with a light infestation of the other. During 1937 several experiments were conducted with mixtures of sulfur and calcium arsenate for control of both the cotton flea hopper and the boll weevil. Efforts were made to determine the effect of these mixtures on each insect with the hope that more economical control could be obtained from combined applications of sulfur and calcium arsenate than from separate applications of each insecticide.

The experiments were of two types, those in which one-acre field plots were used and those in which small plots were arranged in a Latin square. The one-acre plot experiments for flea hopper control were located in the open prairie section of Calhoun County near Port Lavaca, Tex., and similar experiments for boll weevil control were located in the Lavaca River Bottom of Jackson County near Edna, Tex. The cotton was planted early in the season, that is, during the latter part of March and the first part of April. The Latin square experiments were located at Port Lavaca, square 1 in early planted cotton and square 2 in late cotton planted in June.

Experiments on One-Acre Field Plots.—In each of these experiments four one-acre plots were used, three of these plots being dusted, each with a different material, and the fourth plot being left untreated as a check. The experiments were run in series, each series, with the exception of No. 4, consisting of three replications of an experiment. Each plot was 30 rows wide and of sufficient length to cover an acre. The four plots of each experiment were as nearly uniform in regard to their soil, drainage, infestation, size and stand of cotton, and potential production as it was possible to select.

The records of flea hopper infestation were made by counting the numbers of adults and nymphs on 300 main stem terminal buds per plot. The records of boll weevil infestation were made by determining the percentage of punctured squares in 300 squares per plot. The counts of blooms consisted of the number of white blooms on the 10 center rows, or in one-third of each plot. The amount of cotton produced from one-half acre of each plot was carefully weighed for the yield records. The poison applications were made early in the mornings while dew was present, and the dust was distributed through one-nozzle hand dust guns.

The following were materials used for flea hopper control: sulfur; 1:4, 1:2 and 1:1 mixtures of calcium arsenate and sulfur; 1:9 Paris green and sulfur; 7½ per cent Paris green plus 92½ per cent sulfur; and 1:4 cryolite and sulfur.

The materials used for boll weevil control were calcium arsenate; 1:4, 1:2 and 1:1 mixtures of calcium arsenate and sulfur; and 1:9 Paris green and sulfur. In the one-acre plots only the materials giving the most promising results for control of both insects will be discussed; consequently, results of the Paris green plus sulfur mixtures and the cryolite plus sulfur mixture are omitted.

Experiments Against the Cotton Flea Hopper.—The dates of the first dust applications ranged from May 27 to June 12, and of the last applications from June 10 to 19. Each plot received only two effective dust applications. Cut L was dusted four times, but two applications were washed off by rain within 24 hours and were not considered effective. During the period of dusting for flea hoppers there was no injurious infestation of boll weevils in any of the plots. The plots in four experiments (in cuts F, I, M and N) were dusted once with calcium arsenate during the latter part of June for boll weevil control, and those in three experiments (in cuts A, B and H) were dusted twice with calcium arsenate during July

for leaf worm or boll weevil control. These applications were made after the period of flea hopper injury and thus did not affect the comparative results of the different dusts in controlling the flea hopper.

The first record of flea hopper infestation in each experiment was made one or two days prior to the first dust application. Six infestation records were made in cuts A, E, B, F and D by July 6; 5 in cuts I, J and H by July 2; and 4 in cuts L, M and N by July 2.

From five to seven counts of blooms were made in each experiment, the average being 6.2. These records were made at the height of the fruiting of the cotton, or from June 15 to July 16.

Table 1 is a summary of the four series of experiments showing averages of the flea hopper infestation records, bloom counts, dust applications, yield of cotton and net profit* from the different treatments.

Each of the 25 dusted plots showed profitable gains over their respective untreated check plots. The gains ranged from 86 to 532 pounds of seed cotton per acre, the average being 283.8 pounds. The average net profit was $10.47, the range being from $2.29 to $20.91. The infestation records and bloom counts showed that the mixtures of sulfur and calcium arsenate gave slightly better flea hopper control than the sulfur, but the difference was not great enough to overcome the experimental error of soil variation between the plots. Consequently, this advantage was not consistently borne out in yield records. Out of eight experiments, however, where direct comparisons were made of sulfur and the mixtures, four showed higher productions from the mixtures, three showed higher productions from the sulfur and one showed no difference.

Table 1.—Cotton flea hopper control on one-acre field plots in experiments conducted at Port Lavaca, Tex., during 1937.

Experiment	Treatment	Average Number of Flea Hoppers per 100 Buds		Average Number of Blooms per Acre at Each Inspection	Dust Applications, Average per Acre			Yield of Seed Cotton, Average Number of Pounds per Acre	Increased Production in Dusted over Check Plots, Average per Acre		Average Net Profit per Acre Dollars
		Before Dusting	After Dusting Began		Number	Pounds per Application	Cost in Dollars		Pounds	Per Cent	
Series 1, Cuts A, E and I	Check	30.7	77.4	4,035				1,140.0			
	Sulfur	31.9	32.9	6,167	2.0	13.83	1.33	1,380.0	240	21.1	8.93
	20% calcium arsenate+sulfur	40.9	24.8	6,878	2.0	12.96	1.46	1,349.3	209.3	18.4	7.49
Series 2, Cuts B, F, and J	Check	46.7	67.0	3,546				1,089.3			
	20% calcium arsenate+sulfur	36.2	18.5	7,151	2.0	14.38	1.56	1,500.0	410.7	37.7	16.00
	33⅓% calcium arsenate+sulfur	42.7	23.2	6,646	2.0	14.13	1.68	1,447.3	358.0	32.9	13.63
	50% calcium arsenate+sulfur	40.8	26.4	6,503	2.0	13.92	1.82	1,455.3	366.0	33.6	13.83
Series 3, Cuts D, H, and L	Check	28.2	57.2	3,528				952.7			
	Sulfur	31.9	14.5	6,046	2.7	13.81	1.77	1,105.3	152.6	16.0	4.75
	33⅓% calcium arsenate+sulfur	38.3	12.9	6,741	2.7	12.72	2.08	1,149.3	196.6	20.6	6.32
Series 4, Cuts M and N	Check	35.0	55.0	3,444				779.0			
	Sulfur	35.8	12.6	5,855	2.0	15.18	1.41	1,112.0	333.0	42.7	12.83
	50% calcium arsenate+sulfur	37.4	11.5	6,278	2.0	14.08	1.84	1,094.0	315.0	40.4	11.63

BOLL WEEVIL EXPERIMENTS.—Dust applications were made, from June 17, 18 and 19 to July 12, 13 and 14, respectively, at five-day intervals when the boll weevil infestation was above 10 per cent. Several applications washed off by rains within 24 hours were repeated as soon thereafter as possible. From four to five effective applications were made in each experiment, the average being 4.4. An attempt was made to apply from 12 to 14 pounds of each mixture and from 6 to 7 pounds of calcium arsenate at each application, or about the same poundages usually applied for flea hopper and boll weevil control, respectively.

From four to five records of boll weevil infestation were made in each experiment

* In figuring the profit from the dusting operations the following basis was used: Sulfur at 3 cents per pound, calcium arsenate at 6¼ cents per pound, cost of applying the dusts at 25 cents per acre-application, cost of picking at 50 cents per 100 pounds, cost of ginning at 40 cents per 100 pounds, value of the lint at 12 cents per pound, seed at $30 per ton and 35 per cent lint in seed cotton.

between June 16–18 and July 19–26. On an average 6.6 bloom counts were made per experiment, the range being from 6 to 8, from June 21 to July 21–23. Averages of the boll weevil infestation, bloom counts, dust applications, yield of cotton and net profit from the different treatments are given in table 2.

The higher production obtained from the 1:2 and 1:1 mixtures of calcium arsenate and sulfur over the calcium arsenate alone may be explained by a combination of the following factors, each contributing a small part: Better coverage of the cotton plants from applications of higher poundages of the mixtures; the

Table 2.—Boll weevil control in one-acre field plot experiments conducted at Edna, Tex., during 1937.

Experiment	Treatment	Average Per Cent Boll Weevil Punctured Squares		Average Number of Blooms per Acre at Each Inspection	Dust Applications, Average per Acre			Yield of Seed Cotton, Average Number of Pounds per Acre	Increased Production in Dusted over Check Plots, Average per Acre		Average Net Profit per Acre in Dollars
		Before Dusting	After Dusting Began		Number	Pounds per Application	Cost in Dollars		Pounds	Per Cent	
Series A, Cuts 1, 4, and 7	Check	69.8	63.5	2,217	—	—	—	717.3	—	—	—
	20% calcium arsenate+sulfur (1–4)	58.2	28.0	3,927	5.67	12.72	4.09	1,054.0	336.7	46.9	10.31
	33⅓% calcium arsenate+sulfur (1–2)	63.7	17.6	4,262	5.67	13.22	4.54	1,122.3	405.0	56.5	12.77
	50% calcium arsenate+sulfur (1–1)	58.1	14.0	4,527	5.67	12.81	4.87	1,090.3	373.0	52.0	11.08
Series B, Cuts 2, 5, and 8	Check	68.0	67.0	2,095	—	—	—	576.3	—	—	—
	Calcium arsenate	66.8	14.9	4,098	6.33	7.03	4.48	983.0	406.7	70.6	12.91
	33⅓% calcium arsenate+sulfur (1–2)	73.0	18.9	4,675	6.33	14.67	5.46	1,053.3	477.0	82.8	14.94
Series C, Cuts 3, 6, and 9	Check	62.8	67.6	1,628	—	—	—	652.7	—	—	—
	50% calcium arsenate+sulfur (1–1)	59.5	13.0	3,658	6.0	13.67	5.40	1,160.0	507.3	77.7	16.29
	Calcium arsenate	53.6	15.3	3,978	6.0	6.3	3.96	1,110.0	457.3	70.1	15.59

The infestation records show that each of the dusts gave considerable control of the boll weevil, the control being more or less proportionate to the amount of calcium arsenate used. The bloom counts and the yield records show that the addition of sulfur to calcium arsenate, when the minimum average poundage of calcium arsenate in the 1:2 and 1:1 mixtures was not below 4.66 pounds per acre-application (series A and B), increased the fruiting and also the production of the cotton over that of the calcium arsenate alone when used at the rate of 6.68 pounds per acre-application. The net profit was also greater from these two mixtures. The infestation records, bloom counts and yield records show that the 1:4 mixture, which averaged 2.54 pounds of calcium arsenate per acre-application, was not so effective in controlling the boll weevil as either of the other mixtures or the calcium arsenate alone. While the difference in production between the 1:2 and the 1:1 mixtures might well be accounted for as experimental error, it is interesting to note that the 1:2 mixture gave a slightly higher average yield and also a greater net profit than the 1:1 mixture.

effect of sulfur in controlling the light infestation of the mirids present (although infestation records did not show these insects in sufficient numbers to warrant control measures); the beneficial effect of sulfur in controlling diseases of the cotton plant; the slightly reduced cotton aphid infestation where sulfur was used; and the general increased vigor and vitality of the cotton plant where sulfur was used.

LATIN-SQUARE PLOT ARRANGEMENT FOR COTTON FLEA HOPPER AND BOLL WEEVIL CONTROL.—Two experiments were conducted, each consisting of 36 plots, in each of which the Latin square was used. Each plot of square 1 was eight rows wide and of sufficient length to measure one-fortieth acre. There were two rows, or approximately 6 feet, of untreated buffer between the plots. The plots of square 2 were 10 rows wide and one-twentieth acre in size. No buffers were left between these plots. Five insecticides and a check were compared in each square. Each treatment appeared once in each row and once in each column, making six replications per experiment.

Poison applications were made in square 1 on the following dates: June 11, 18 and

25, and July 2 and 14. The kind and average amount of dust that each plot received per application were as follows: Check, none; sulfur, 0.396 pound; 1:9 mixture of Paris green and sulfur, 0.401 pound; 1:4 mixture of calcium arsenate and sulfur, 0.396 pound; 1:2 mixture of calcium arsenate and sulfur, 0.401 pound; and 1:1 mixture of calcium arsenate and sulfur, 0.391 pound.

Poison applications were made in square 2 on the following dates: July 15, 20, 26 and 31, and August 5, 10 and 23. The kind and average amount of dust that each plot received per application were as follows: check, none; sulfur, 0.788 pound; 1:9 mixture of Paris green and sulfur, 0.770 pound; 1:4 mixture of calcium arsenate and sulfur, 0.805 pound; 1:2 mixture of calcium arsenate and sulfur, 0.815 pound; and calcium arsenate, 0.411 pound.

Records of cotton flea hopper infestation were made by inspecting 100 terminal buds on the middle rows of each plot and noting the number of live adults and nymphs present. Five such records were made in square 1 at weekly intervals between June 10 and July 8. Three records of flea hopper infestation were made in square 2 on July 14, 23 and 30. The average infestation on each plot during the dusting period—four records in square 1 and two records in square 2—was used in the analysis of variance of flea hopper infestation.

The record of boll weevil infestation was taken by inspecting 100 squares on the middle rows of each plot and noting the percentage punctured. These records were taken on June 17 and 24 and July 1, 8, 13 and 20 in square 1 and on July 30 and August 6, 14 and 19, and September 2 in square 2. Averages of the six records made in each plot of square 1 and of the five records made in each plot of square 2 were used in the analysis of variance.

The yields were obtained by picking the four middle rows, one-eightieth acre, of each plot of square 1 and five rows, one-fortieth acre, of each plot of square 2 and recording the actual weight of seed cotton produced.

RESULTS.—The data obtained from the flea hopper infestation records, boll weevil infestation records and yield records were analyzed by the method of analysis of variance.† Tables 3 and 4 show the means and the required difference between any treatment and the standard for significance in Latin squares 1 and 2.

Table 3.—Mean cotton flea hopper infestation, mean boll weevil infestation and mean yield for the six treatments and the difference between any mean and the standard necessary for significance in Latin square 1 at Port Lavaca, Tex., 1937.

TREATMENT	NUMBER OF HOPPERS IN FLEA HOPPER INFESTATION	PER CENT PUNCTURED SQUARES IN BOLL WEEVIL INFESTATION	YIELD OF SEED COTTON, POUNDS PER 1/80 ACRE
Sulfur plus calcium arsenate (1–1)	26.2	33.9	31.21
Sulfur plus calcium arsenate (2–1)	25.7	35.0	13.54
Sulfur plus calcium arsenate (4–1)	27.8	40.5	12.26
Sulfur plus Paris green (9–1)	21.4	39.5	12.18
Sulfur	31.1	42.8	10.69
Check	49.9	40.4	10.06
For significance a treatment must differ from the standard by	*4.64*	*3.54*	*0.82*

Where the flea hopper infestation was high and damage occurred over a long period (square 1), the 1:1 mixture of calcium arsenate and sulfur, the 1:2 mixture of calcium arsenate and sulfur and the 1:9 mixture of Paris green and sulfur gave significantly better control than sulfur alone; but where the flea hopper infestation was low and was quickly reduced below the damage point (square 2), the sulfur-arsenical mixtures gave no better control than sulfur alone. Apparently sulfur alone gives adequate flea hopper control when the infestation is low, while the sulfur-arsenical mixtures are more effective against high infestations.

The 1:1 mixture of calcium arsenate and sulfur (rate of 7.8 pounds of calcium arsenate per acre-application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.35 pounds of calcium arsenate

† Thanks are due Dr. J. C. Gaines, College Station, Tex. for the analysis of variance reported in this paper.

per acre-application) in square 1, and calcium arsenate alone (rate of 8.22 pounds per acre-application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.43 pounds of calcium arsenate per acre-application) in square 2, were equally effective in controlling boll weevils and each gave significant control. Neither the 1:4 mixture of calcium arsenate and sulfur (rate of 3.2 pounds of calcium arsenate per acre-application), nor the 1:9 mixture of Paris green and sulfur, nor sulfur alone was so effective in controlling boll weevils as the insecticides previously mentioned. The weevil infestation was higher, but not significantly higher, on the sulfur-treated plots than on the checks in both square 1 and square 2. In the 12 rows or individual plot comparisons of squares 1 and 2 the infestation was higher on the sulfur-treated plots in 10 of the 12 rows. The significance of this occurrence will be determined only after further experiments have been conducted and analyzed.

In square 1 the 1:1 mixture and the 1:2 mixture of calcium arsenate and sulfur each gave significantly higher yields than sulfur alone because these mixtures gave significantly better control of both flea hoppers and boll weevils. The Paris green plus sulfur mixture also gave a significant increase in yield over the sulfur because the flea hopper control was better from the mixture than from sulfur alone. The 1:4 mixture of calcium arsenate and sulfur gave better, but not significantly better, control of both flea hoppers and boll weevils than sulfur alone. The slightly better control of both insects caused the significant increase in yield over that from the sulfur. Sulfur did not give an increase in yield over the checks because of the higher boll weevil infestation that occurred on the sulfur treated plots.

In square 2 calcium arsenate gave a significantly higher yield than any of the other insecticides used. The yield in the plots treated with calcium arsenate was higher than in the plots treated with the 1:2 mixture of calcium arsenate and sulfur because of the significantly better bollworm control. Bollworm infestations occurred only in square 2. Calcium arsenate was applied at the rate of 8.22 pounds per acre-application while only 5.43 pounds of calcium arsenate was applied per acre-application in the 1:2 mixture. This 5.43 pounds of calcium arsenate per acre was ample to give effective control of the boll weevil but was not enough to control the bollworm. The 1:2 mixture of calcium arsenate and sulfur gave a significantly higher yield than the 1:4 mixture, the Paris green plus sulfur mixture, or sulfur alone, owing to the better boll weevil control obtained from the 1:2 mixture.

Table 4.—Mean cotton flea hopper infestation, mean boll weevil infestation, mean bollworm infestation and mean yield for the six treatments and the difference between any mean and the standard necessary for significance in Latin square 2 at Port Lavaca, Tex., 1937.

Treatment	Number of Hoppers in Flea Hopper Infestation	Per Cent Punctured Squares in Boll Weevil Infestation	Per Cent Injured Squares in Bollworm Infestation	Yield of Seed Cotton, Pounds per 1/40 Acre
Calcium arsenate	19.75	28.07	6.70	13.78
Sulfur plus calcium arsenate (2–1)	14.08	29.77	12.50	10.94
Sulfur plus calcium arsenate (4–1)	15.25	39.90	14.40	7.89
Sulfur plus Paris green (9–1)	11.50	45.33	15.23	6.69
Sulfur	12.50	47.50	18.72	5.75
Check	34.33	44.67	8.05	7.74
For significance a treatment must differ from the standard by	*3.5*	*4.4*	*4.04*	*1.33*

SUMMARY.—Mixtures of calcium arsenate and sulfur, 1:1, 1:2 and 1:4 proportions, were tested in 1-acre-field-plot experiments along with sulfur for cotton flea hopper control and with calcium arsenate for boll weevil control. The infestation records and bloom counts showed that the mixtures gave slightly better flea hopper control than the sulfur but the difference was not great enough to overcome the experimental error be-

tween the plots or show consistent gains in yield. In the 1-acre experiments for boll weevil control the bloom counts and yield records showed that the addition of sulfur to calcium arsenate, when the minimum average poundage of calcium arsenate was not below 4.66 pounds per acre-application (1:2 and 1:1 mixtures of calcium arsenate and sulfur), increased the fruiting and also the production of the cotton over that of calcium arsenate alone when used at the rate of 6.68 pounds per acre-application. The net profit was also greater from these two mixtures. The infestation records, bloom counts and yield records each showed that the 1:4 mixture, which averaged 2.54 pounds of calcium arsenate per acre-application, was not so effective in controlling the boll weevil as either of the other mixtures or calcium arsenate alone.

Two experiments were conducted for flea hopper and boll weevil control in which small plots (one-fortieth and one-twentieth acre, respectively) were arranged in Latin squares. Where the flea hopper infestation was high and damage occurred over a long period (square 1), the 1:1 mixture and the 1:2 mixture of calcium arsenate and sulfur gave significantly better control than sulfur alone; but where the flea hoppers decreased rapidly after dusting began and caused only light damage (square 2), the sulfur-arsenical mixture gave no better control than sulfur alone. Apparently sulfur alone gives adequate flea hopper control when the infestation is low, while the sulfur-arsenical mixtures are more effective against high infestations.

The 1:1 mixture of calcium arsenate and sulfur (rate of 7.8 pounds of calcium arsenate per acre-application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.35 pounds of calcium arsenate per acre-application) in square 1, and calcium arsenate alone (rate of 8.22 pounds per acre-application) and the 1:2 mixture of calcium arsenate and sulfur (rate of 5.43 pounds of calcium arsenate per acre-application) in square 2 were equally effective in controlling boll weevils and each gave significant control. The 1:4 mixture of calcium arsenate and sulfur (rate of 3.2 pounds of calcium arsenate per acre-application) was not so effective in controlling boll weevils as the insecticides above mentioned.—2-18-38.

The Relation of Wind Currents, as Indicated by Balloon Drifts, to Cotton Flea Hopper Dispersal*

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Investigations have shown that the cotton flea hopper, *Psallus seriatus* (Reut.), transfers in spring from native food plants to cotton. Screen traps and population counts show that in southcentral Texas adult flea hoppers begin to drift into cotton in small numbers during April, although most of the dispersal usually occurs from about the middle of May until the first part of June. This insect is small, delicate and, theoretically at least, incapable of long, self-sustained flights. Where do these insects come from?

LONG-DISTANCE DISPERSAL INDICATED.—*Croton* is the principal overwintering host plant of the cotton flea hopper. Hibernation studies show that a very large percentage of all nymphs that emerge in southcentral Texas in the spring come from overwintering eggs laid in this plant. *Croton* grows much more abundantly in the lighter type or sandy soils than in the heavy black land, whereas more flea hopper injury occurs on cotton growing in the black-land areas of Texas.

During the period 1933–37 a tall *Tanglefoot* trap was operated in the vicinity of College Station, Tex. The trap extended 26 feet into the air and had four sections each with a 3-foot by 5-foot trapping surface, facing each of the cardinal directions. There was a space of 1 foot between each 5-foot section, for free circulation of air. Two somewhat similar traps were operated at Port Lavaca from 1935 to 1937, inclusive, to obtain informa-

* Technical Contribution 430, Texas Agricultural Experiment Station.

tion on the number of flea hoppers that were drifting through the air at different altitudes. At College Station a little over one-half of the total number of flea hoppers (adults) captured on the tall trap during April and May of the 5-year period were captured on the highest section of the trap. The catch from the top section (21 to 26 feet from the ground) was 311, or 52.8 per cent of the total of 589 captured on the entire trap. The next highest catch was 21.1 per cent from the section 15 to 20 feet from the ground; 13.4 per cent were captured on the section 9 to 14 feet from the ground, and the lowest catch was 75, or 12.7 per cent, from the section 3 to 8 feet from the ground. These records show that flea hoppers drift through the air more abundantly at 26 feet from the ground than nearer the surface. While the total catches from the high traps at Port Lavaca during April and May in 1935, 1936 and 1937 did not show the same percentages of flea hoppers captured from the different elevations—owing no doubt to more local movement of the insects in the cotton surrounding these traps—they did show that during certain periods, when population counts indicated definite dispersals, more flea hoppers were captured on the top sections than on the others.

Another indication of long-distance dispersal was the catch of flea hoppers from 20 to 2,000 feet in the air by an airplane. Forty-four adult flea hoppers were caught by Bureau airplanes equipped with specially constructed insect traps at the following elevations: 13 at 20 to 25 feet, 1 at 50 feet, 13 at 200 feet, 13 at 500 feet, 3 at 1,000 feet and 1 at 2,000 feet. Thirty-seven of the flea hoppers were caught in a few hours' flying time in the vicinity of College Station, Tex., from May 5 to 16, 1931, while the other seven were caught in the vicinity of Tallulah, La., in 1,007 hours flown during 1926 to 1931. Twenty nymphs were also captured on the airplane traps, 1 at 200 feet elevation and 18 at 500 feet at College Station, and 1 at 20 feet at Tallulah.

During the winter of 1933–34 approximately 10,000 acres of *Croton* weeds, the principal overwintering host plant of the cotton flea hopper, were destroyed in Calhoun County, Tex. This clean-up campaign was made possible through funds furnished by the Civil Works Administration. Practically all *Croton* weeds were destroyed within the main cotton growing area of the county and in the ranch country immediately surrounding the cotton growing area. Observations, screen-trap readings and counts of flea hopper populations on weed hosts and cotton showed that the initial infestation was considerably reduced in the cleaned-up area but

Table 1.—Data on balloons released in seventeen counties of Texas in cotton flea hopper dispersal studies.

COUNTIES IN WHICH RELEASES WERE MADE	NUMBER OF BALLOONS RELEASED	NUMBER OF TAGS RECOVERED	PER CENT RECOVERED	AVERAGE DRIFT, MILES	MAXIMUM DRIFT, MILES
Austin	150	16	10.7	33.4	63
Bastrop	254	35	13.8	34.5	76
Brazos	365	43	11.8	43.4	160
Brooks	150	5	3.3	41.0	63
Caldwell	50	7	14.0	30.9	50
Calhoun	410	21	5.1	33.8	82
Colorado	200	30	15.0	28.8	81
De Witt	200	20	10.0	39.0	82
Goliad	200	17	8.5	52.6	85
Gonzales	150	19	12.7	110.1	330*
Kleberg	100	2	2.0	24.0	24
Lavaca	200	33	16.5	50.1	375
Lee	250	47	18.8	27.6	75
Leon	10	2	20.0	26.0	26
Milam	145	16	11.0	67.0	165
Nueces	325	17	5.2	26.3	99
Robertson	175	16	9.1	56.0	93
Total and average	*3,334*	*346*	*10.4*	*42.9*	

* Another balloon released on Gonzales County drifted 318 miles.

that there was a heavy dispersal of adult flea hoppers into cotton from outside this area, this heavy dispersal beginning the second week of May. This experiment showed that flea hoppers drifted with the wind from native food plants to cotton a distance of at least 20 miles.

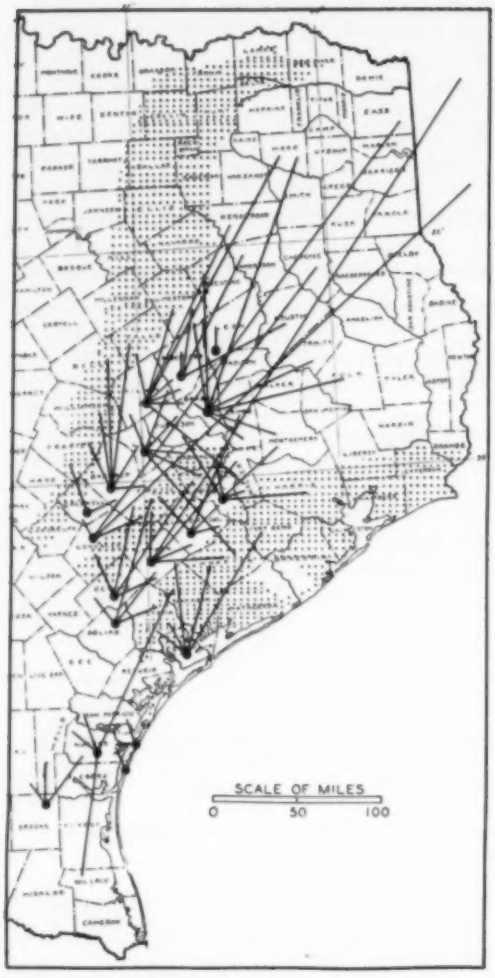

FIG. 1.—Map showing location of balloon releases (large dots) and direction of drift (lines) as indicated by recovered tags. The dotted areas designate the heavy soils.

BALLOON RELEASES.—To obtain information on the wind currents as a further aid in the study of flea hopper dispersal, 3,334 balloons were released between May 14 and June 12, 1937, in 17 counties in southcentral Texas. This was a cooperative project between the Texas Agricultural Experiment Station, College Station, Tex., and the Port Lavaca, Tex., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, the state furnishing the balloons and the hydrogen that was used to inflate them and the Bureau furnishing the serially numbered, return-addressed, franked tags that accompanied the balloons. By the use of special regulating valves that were attached to the cylinders of hydrogen it was easy to inflate a balloon to any desired size in a few seconds' time. The sizes of the released balloons ranged from 8 inches in diameter, which was the minimum buoyancy, to approximately 10 inches. The mouth of the balloon was firmly tied with a soft, wet string attached to a tag. The inscription on the tag requested the finder to return it, and to give the name and address of the finder and the date, time of day and place where the tag was found.

Balloon releases were made in areas of light or sandy soil where *Croton* grows abundantly. In most cases from three to four releases were made at about weekly intervals from each location, and from 25 to 50 balloons were released at a time. The area was divided so that the personnel from the Port Lavaca laboratory made releases in the southern section and the personnel from the Experiment Station at College Station made releases in the northern section.

RECOVERIES.—Table 1 shows the counties from which releases were made, the number of balloons released from each county, the number of tags recovered, the percentages of recovery, and the average and maximum drift. An average of 10.4 per cent of the tags was recovered to October 30, 1937. The maximum drift attained by any recovered balloon was 375 miles. This balloon was released from Hallettsville, Lavaca County, Tex., at 2:49 p.m. on June 2, and was recovered at 9 a.m., June 3, at Waldo, Ark. Another balloon, released from Gonzales, Tex., at 4:48 p.m. June 2, was recovered at 1 p.m., June 3, at Gibsland, La., after traveling a distance of 330 miles. The majority of the tag recoveries, however, were from comparatively short distances from the points of release, the average drift of all balloons being 42.6 miles. The prevailing direction of the drift was to the north and northeast from the light soils across and into the heavy soils, fig. 1.

Each of three balloons drifted over 300 miles, an average of 341 miles in 19 hours, or 17.9 miles per hour. In one case a balloon drifted 155 miles in 5 hours and 12 minutes, or an average of 29.8 miles per hour. Twelve of the balloons found on the same day that they were released drifted from 50 to 75 miles, an average of 62.4 miles in 4.7 hours, or 13.3 miles per hour. These experiments indicate that within a comparatively short period of time adult flea hoppers could easily drift or be carried by wind currents for long distances from the flea hopper infested fields of *Croton* weeds to cotton and native spring food plants.

SUMMARY.—Catches on tall traps show that adult flea hoppers are found in fairly large numbers 21 to 26 feet in the air. Collections made by airplane show adult flea hoppers as high as 2,000 feet above the ground. A heavy dispersal of flea hoppers into cotton in Calhoun County, Tex., from outside the area which was cleaned of *Croton* shows that the dispersal of this insect is at least 20 miles. The prevailing wind currents in southcentral Texas, as indicated by balloon drifts in 1937, are to the north and northeast from the light-soil areas toward the heavy-soil areas. One balloon drifted 155 miles at an average rate of 29.8 miles per hour. Twelve balloons found on the same day that they were released drifted an average of 62.4 miles at the rate of 13.3 miles per hour. The average drift of 346 balloons recovered from 3,334 releases was 42.6 miles.

In view of the above facts, it is logical to believe that adult flea hoppers may transfer long distances from their spring host plants, which grow abundantly in the light-soil area, to cotton and other native spring food plants in the heavy-soil areas, thereby accounting for the injurious infestations in large areas of cotton which are comparatively free of initial infestations of flea hoppers early in the spring.—2-18-38.

Effectiveness of Several Insecticides Against Three Cotton Insects

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The efficacy of various insecticides and mixtures of insecticides against three cotton insects, the boll weevil, *Anthonomus grandis* Boh., the cotton leaf worm, *Alabama argillacea* (Hbn.), and the tarnished plant bug, *Lygus pratensis* (L.), was studied at Tallulah, La., in 1937. The tests were made under cage conditions and were a continuation of tests made the previous season, the methods and results of which have been discussed by Smith & Scales (1937). In the tests reported herein the net mortality in each cage was computed by using the formula $\frac{(X-Y)100}{X}$ with X the percentage of live insects in the check cage and Y the percentage in the treated cage. Analysis of variance was then used to determine the required difference for significance between the net mortalities of treatments.

TESTS OF VARIOUS BRANDS OF CALCIUM ARSENATE.—The results of tests with 20 brands of commercial calcium arsenate against the boll weevil and the cotton leaf worm, together with averages when divided into three groups according to high, medium and low mortality to boll weevils, are presented in table 1. The physical properties of these calcium arsenates have been reported by Goodhue (1937) and the chemical properties by Nelson & Cassil (1937). Some of these properties are included in the table. The tests against the boll weevil were based upon 21 replications in 1936 and the same number in 1937. The average mortality in the checks was 22 per cent in 1936 and 20 per cent in 1937. The tests against the cotton leaf worm were based upon 15 replications in 1937, and the average mortality in the checks was 9 per cent.

Table 2 presents correlation coefficients between average net mortality (1936 and 1937) of boll weevils and ten physical and chemical properties. In the last column the levels of significance represented by

* The authors were assisted in the field by W. R. Stanley, G. C. Woodruff, T. T. Carter, and H. C. Massey.

Table 1.—Cage tests against the boll weevil and the cotton leaf worm with 20 brands of commercial calcium arsenate.

Sample No.*	I. D. No.	Total As_2O_5 Per Cent	Water-Soluble As_2O_5		Particle Size, Per Cent Below 5 Micron Radius	Density at 25° C., Grams Per CC.	Molar Ratio CaO/As_2O_5	Net Mortality			
			A.O.A.C. Method, Per Cent	N. Y. Method, Per Cent				Boll Weevil			Leaf Worm
								1936 Per Cent	1937 Per Cent	Average Per Cent	1937 Per Cent
B	3174	43.57	0.18	11.5	35	2.98	3.11	90	80	85	94
A	3171	42.87	0.11	6.4	52	3.01	3.25	78	73	76	95
D	3197	41.21	0.11	7.6	34	2.98	3.15	76	73	75	95
Q	3215	42.31	0.08	6.8	49	3.04	3.46	70	74	72	94
P	3214	42.19	0.08	6.1	48	3.02	3.37	69	68	69	94
S	3220	45.31	0.08	4.2	58	3.11	3.43	70	66	68	89
K	3207	46.38	0.15	3.5	57	3.14	3.20	69	67	68	92
E	3201	40.19	0.08	8.7	39	2.95	3.07	69	66	68	94
C	3191	45.34	0.04	0.5	90	3.28	3.49	75	59	67	89
H	3204	41.52	0.30	3.2	62	3.14	3.47	68	61	65	95
N	3210	42.02	0.05	1.9	62	3.10	3.76	61	69	65	97
L	3208	41.00	0.11	6.0	57	3.05	3.39	59	69	64	95
I	3205	41.99	0.09	7.9	45	3.00	3.20	56	69	63	92
R	3216	42.81	0.08	0.7	71	3.12	3.66	63	60	62	92
U	3353	43.29	0.23	0.6	58	3.13	3.60	56	51	54	79
O	3211	40.77	0.15	1.	67	3.15	3.41	51	53	52	86
F	3202	40.98	0.08	6.3	59	2.99	3.35	56	41	49	92
J	3206	43.26	0.11	3.2	58	3.07	3.45	45	53	49	93
G	3203	40.71	0.08	0.2	93	3.14	3.77	40	29	35	73
M	3209	43.14	0.11	0.6	92	3.32	3.53	21	32	27	33
Average of group:											
B,A,D,Q,P,S and K		*43.41*	*0.11*	*6.6*	*48*	*3.04*	*3.28*	—	—	*73*	*93*
E,C,H,N,L,I and R		*42.12*	*0.11*	*4.1*	*61*	*3.09*	*3.43*	—	—	*65*	*93*
U,O,F,J,G and M		*42.03*	*0.13*	*2.0*	*71*	*3.13*	*3.52*	—	—	*44*	*76*
For significance, two treatments must differ by								*15*	*13*	*10*	*9*

* According to Goodhue (1937) and Nelson & Cassil (1937).

P were taken from Fisher's table V, A (1936). If P is less than .05, the coefficients are considered significant and if less than .01 they are considered highly significant; if more than .05 they are not considered significant. Significant correlation coefficients were found between net mortality and particle size, net mortality and density, net mortality and water-soluble As_2O_5 by the New York method, and net mortality and molar ratio CaO/As_2O_5. The coefficients between net mortality and particle size and between net mortality and water-soluble As_2O_5 by the New York method were highly significant. Correlation coefficients that are not considered significant were found between net mortality and angle of slope, net mortality and loose bulking value at constant weight, net mortality and loose bulking value at constant volume, net mortality and total As_2O_5, net mortality and water-soluble As_2O_5 by the A.O.A.C. method, and net mortality and free $Ca(OH)_2$.

These tests showed that the calcium arsenates with the following physical and chemical properties caused the highest mortalities of boll weevils: coarse as to particle size, low density, high water-soluble As_2O_5 by the New York method, and low molar ratio CaO/As_2O_5. According to the Division of Insecticide Investigations of this Bureau, the apparent anomaly that the finer materials are less toxic than the coarser ones is probably to be explained on the basis of the findings of

Table 2.—Average net mortality of boll weevils in cages correlated with 10 physical and chemical properties of commercial calcium arsenates.

Property of Calcium Arsenate	Correlation Coefficient	Levels of Significance Represented by P in Fisher's Table V. A.
Particle size, per cent below 5 micron radius	−.73	Less than .01
Density at 25 degrees C., grams per cc.	−.56	Between .02 and .01
Angle of slope, degrees	+.22	More than .10
Loose bulking value, constant weight	−.28	More than .10
Loose bulking value, constant volume	−.30	More than .10
Molar ratio CaO/As_2O_5	−.55	Between .02 and .01
Total As_2O_5	+.20	More than .10
Water-soluble As_2O_5, A. O. A. C. method	+.05	More than .10
Water-soluble As_2O_5, N. Y. method	+.65	Less than .01
Free $Ca(OH)_2$	+.05	More than .10

Nelson & Cassil (1937). These authors showed that, in general, the particles are larger in those samples having low ratios of CaO/As_2O_5, and consequently containing larger proportions of the more acid compounds, whose solubilities are known and chemical properties as angle of slope, loose bulking value at constant weight, loose bulking value at constant volume, total As_2O_5, water-soluble As_2O_5 by the A.O.A.C. method, and free $Ca(OH)_2$.

In another series of experiments nine

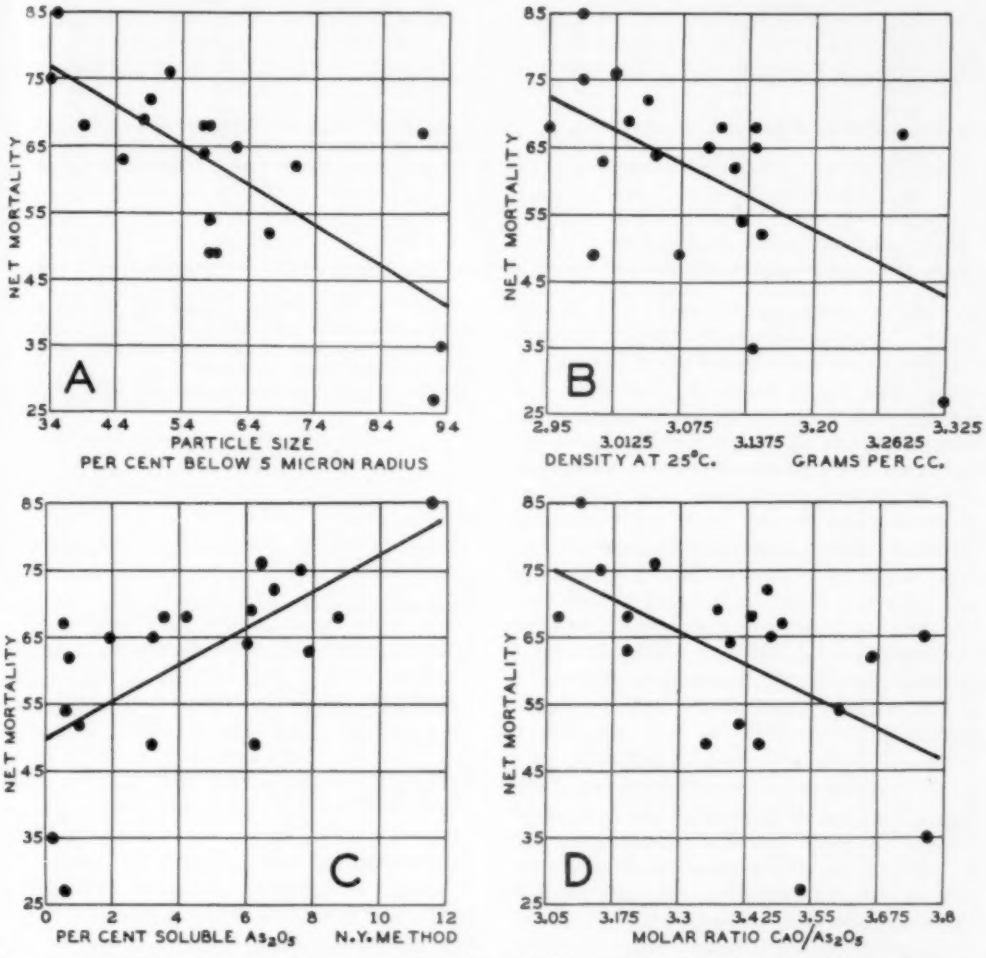

FIG. 1.—A, Particle size versus average net mortality of boll weevils; B, Density at 25 degrees C. versus average net mortality of boll weevils; C, Water-soluble As_2O_5 by the New York method versus average net mortality of boll weevils; D, Molar ratio CaO/As_2O_5 versus average net mortality of boll weevils; 1936 and 1937.

to be of a higher order than those of the more basic arsenates. In other words, the chemical differences among the samples tend to overshadow the normal effect of particle size.

The relations that were found to be significant are further illustrated in fig. 1 with straight lines fitted by the method of least squares. There do not appear to be any significant relations between net mortality of boll weevils and such physical

different brands of commercial calcium arsenate were tested against boll weevils and ten brands of calcium arsenate were tested against cotton leaf worms. The net mortalities, together with the total As_2O_5 and water-soluble As_2O_5 by the A.O.A.C. and the New York methods,† are shown in table 3. The net mortalities of boll weevils were based upon 24 replications,

† All chemical analyses reported in this paper were furnished by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

Table 3.—Tests against the boll weevil and cotton leaf worm with 10 brands of commercial calcium arsenate.

I. D. Sample No.	Total As_2O_5, Per Cent	Water-Soluble As_2O_5		Net Mortality	
		A.O.A.C. Method, Per Cent	N. Y. Method, Per Cent	Boll Weevil, Per Cent	Leaf Worm, Per Cent
3689	42.5	0.16	10.00	72	96
3681	40.3	0.09	5.00	72	93
3683	42.6	2.75	4.10	67	95
3698	44.7	0.20	8.40	52	94
3680	44.5	0.11	0.85	49	85
3713	46.2	0.00	0.30	48	83
3679	45.8	0.14	0.80	47	90
3715	41.6	0.30	0.90	42	81
3714	40.9	0.20	0.50	39	85
3671	40.5	0.14	0.37	—	78
For significance two treatments must differ by				*12*	*11*

and the average mortality in the checks was 22 per cent. The tests against the cotton leaf worm were based upon 12 replications, and the average mortality in the checks was 8 per cent. Here again the relation between water-soluble As_2O_5 by the New York method and net mortality of boll weevils is apparent, the coefficient of correlation being +.72 (P = between .05 and .02). There also appears to be some relation between the water-soluble As_2O_5 by the New York method and cotton leaf worm mortality, the samples having the highest water-soluble As_2O_5 causing the highest mortalities and those of low water-soluble As_2O_5 causing lower mortalities.

TESTS WITH CALCIUM ARSENATE AND LEAD ARSENATE, ALONE AND WITH CARRIERS.—Table 4 presents the net mortalities of boll weevils for three commercial calcium arsenates, lead arsenate, and mixtures of calcium arsenate and of lead arsenate with different carriers. The net mortalities were based upon 20 replications, and the average mortality in the checks was 16 per cent. In general these tests indicated that the net mortality of boll weevils decreased, with both lead arsenate and calcium arsenate, as the proportion of filler was increased. There was not a significant difference between the mortality caused by undiluted lead arsenate and two of the calcium arsenates, but there was a significant difference between lead arsenate and calcium arsenate I.D. 3737, which caused a significantly higher mortality than lead arsenate. It is interesting to note that the sample of calcium arsenate having the highest water-soluble As_2O_5 by the New York method

Table 4.—Tests against the boll weevil with three commercial calcium arsenates, lead arsenate, and mixtures of calcium arsenate and of lead arsenate with carriers.

Insecticide		Net Mortality, Per Cent
Calcium arsenate alone:		
I.D. 3672*		56
I.D. 3671†		43
I.D. 3737‡		72
Lead arsenate alone, I.D. 3674§		48
Calcium arsenate (I.D. 3672) mixture:		
With sulfur	(1:1)	43
	(1:2)	41
	(1:4)	38
With lime	(1:1)	38
Calcium arsenate (I.D. 3671) mixture:		
With lime	(1:1)	39
	(1:2)	34
	(1:4)	47
With clay	(1:1)	56
	(1:2)	47
	(1:4)	36
Lead arsenate (I.D. 3674) mixture:		
With sulfur	(1:1)	51
	(1:2)	44
	(1:4)	39
With lime	(1:1)	52
	(1:2)	33
	(1:4)	33
For significance two treatments must differ by		*13*

* Total As_2O_5, 43.5; water-soluble As_2O_5 by A.O.A.C. method, 0.11; by New York method, 0.40 per cent.
† Total and water-soluble As_2O_5 as given in table 3.
‡ Total As_2O_5, 42.1; water-soluble As_2O_5 by A.O.A.C. method, 0.03; by New York method, 0.86 per cent.
§ Total As_2O_5, 31.1; water-soluble As_2O_5 by A.O.A.C. method, 0.22 per cent.

caused the highest mortality and the sample having the lowest water-soluble As_2O_5 caused the lowest mortality.

TESTS WITH CALCIUM ARSENATE, CRYOLITE AND SULFUR.—Table 5 presents net mortalities of boll weevils and of cotton leaf worms caused by a commercial calcium arsenate and four samples of cryolite and net mortalities of tarnished plant bugs caused by sulfur and four samples of tests against the tarnished plant bug the value of F (Snedecor 1934) was found to be 1.06. This nonsignificant F means that the samples do not vary more than would be expected had they been drawn from a homogeneous population.

SUMMARY OF RESULTS.—Definite correlations are shown between net boll weevil mortality and the following physical and chemical properties of calcium

Table 5.—Tests against the boll weevil, cotton leaf worm and tarnished plant bug with four cryolites, one commercial calcium arsenate and one dusting sulfur.

SAMPLE	FLUORINE FOUND, PER CENT	EQUIVALENT TO CRYOLITE Na_3AlF_6, PER CENT	NET MORTALITY		
			Boll Weevil, Per Cent	Leaf Worm, Per Cent	Tarnished Plant Bug, Per Cent
Calcium arsenate I.D. 3671*	—	—	39	86	—
Cryolite I.D. 3668	38.0	69.9	13	64	12
Cryolite I.D. 3670	8.6	15.8	10	17	16
Cryolite I.D. 3667	16.5	30.3	8	31	22
Cryolite I.D. 3669	8.3	15.2	2	23	10
Sulfur	—	—	—	—	13
For significance two treatments must differ by			*12*	*21*	

* See table 5 for analysis.

cryolite. The boll weevil tests were based upon nine replications, and the average mortality in the checks was 11 per cent. The cotton leaf worm tests were based upon nine replications and the average mortality in the checks was 7 per cent. The tarnished plant bug tests were based upon 15 replications, and the average mortality in the checks was 26 per cent. Against the boll weevil there was a significant difference in favor of calcium arsenate when compared with the four cryolites, but there was no significant difference between the four cryolites. Against the cotton leaf worm there was a significant difference in favor of calcium arsenate when compared with the four cryolites, and also between some of the cryolites. The mortalities of both cotton leaf worms and boll weevils caused by the cryolites appeared, in general, to be in direct proportion to the percentage of cryolite Na_3AlF_6 in the samples. In the arsenate: particle size, density, water-soluble As_2O_5 by the New York method, and molar ratio CaO/As_2O_5. There appeared to be no significant correlations between such physical and chemical properties of calcium arsenate as angle of slope, loose bulking value at constant weight and constant volume, total As_2O_5, water-soluble As_2O_5 by the A.O.A.C. method, and free $Ca(OH)_2$. The effectiveness of both calcium arsenate and lead arsenate seems to vary inversely with the amount of carrier added. Calcium arsenate showed significantly higher net mortalities of boll weevils and cotton leaf worms than the four cryolites that were tested. There appeared to be a definite relation between net mortality and the amount of cryolite Na_3AlF_6 in the various samples of cryolite. In general, the highest percentages caused the highest net mortalities of boll weevils and leaf worms, though none was effective.—2-18-38.

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Test of Insecticides for Control of the Boll Weevil, With and Without Untreated Checks

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In control measures to be used against the boll weevil, *Anthonomus grandis* Boh., several insecticides are known to be of value. Before control measures are recommended, however, it is essential that an accurate comparison of these be made, and the cheapest, most effective and most practical one adopted.

During the 1937 growing season two experiments were conducted near Florence, S. C., in an effort to determine accurately the relative value of several insecticides against the boll weevil. Each experiment consisted of six treatments, each treatment replicated six times on one-tenth acre plots arranged in a Latin square. In experiment 1, six insecticides were used whereas in experiment 2 five insecticides and an untreated check were used. The insecticides used in both experiments were dusts.

DATA OBTAINED.—Records of average percentages of seasonal infestation were made by examining 100 squares in each plot at three- to four-day intervals throughout the fruiting period; the number of living boll weevils seen in each plot was noted while the infestation records were being made; the number of white blooms was counted on the ten center rows in each plot at three- to eight-day intervals throughout the blooming period; and the total number of bolls present on the two center rows in each plot was counted at the end of the fruiting period. A record of the number of pounds of seed cotton produced on the ten center rows of each plot was obtained for experiment 2.

The average seasonal infestation (average of 12 and 14 counts, respectively, for experiments 1 and 2) and the total number of blooms counted (7 and 8 counts, respectively, for experiments 1 and 2) are considered the more reliable criteria in determining the relative effectiveness of the insecticides used in these experiments.

EXPERIMENT 1.—In experiment 1 the following six insecticidal dusts were used without checks or untreated plots: (1) calcium arsenate, (2) 50–50 calcium arsenate plus lime, (3) $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime, (4) 50–50 calcium arsenate plus sulfur, (5) 10–90 pyrethrum plus sulfur and (6) 36 per cent cryolite. The data are summarized in table 1.

From table 1 it may be seen that every other treatment is better than the pyrethrum plus sulfur treatment, the value being highly significant in practically every instance for each criterion and in every instance where calcium arsenate or any of its dilutions occur. Calcium arsenate, 50–50 calcium arsenate plus lime, and 50–50 calcium arsenate plus sulfur are better than the 36 per cent cryolite, according to seasonal infestation records and bloom counts. The difference between $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime mixture and the 36 per cent cryolite is not significant according to either criterion. Calcium arsenate shows a highly significant difference over $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime, according to seasonal infestation records and bloom counts. There is a significant difference in seasonal infestation records between calcium arsenate and 50–50 calcium arsenate plus lime, while the difference in bloom counts is highly significant. No significant difference is shown between calcium arsenate and 50–50 calcium arsenate plus sulfur.

A heavy aphid infestation occurred in all the plots except those treated with the pyrethrum plus sulfur mixture, causing considerable shedding of both leaves and bolls. Because of this the boll count is not so reliable as the seasonal infestation or the bloom counts.

Table 1.—Summary of infestation counts, bloom counts, boll weevil counts and insecticide applications, together with minimum differences required to give chances of 19 to 1 and 99 to 1, respectively.

Insecticide Used	Average Number of Pounds Insecticide Applied per Acre (Average of Eight Applications)	Average Seasonal Infestation per Plot, Per Cent	Total Number of Blooms per Plot	Total Number of Live Weevils per Plot	Total Number of Bolls per Plot
Calcium arsenate	9.25	14.00	2149	23.8	1493
1:1 Calcium arsenate plus lime	8.24	19.88	1884	26.7	1399
1:2 Calcium arsenate plus lime	8.18	21.46	1765	30.2	1410
1:1 Calcium arsenate plus sulfur	12.76	16.27	2013	20.2	1470
10:90 Pyrethrum plus sulfur	11.93	32.18	1265	47.5	1223
36% Cryolite	9.23	25.45	1626	32.3	1350
Minimum difference between treatments required for a probability of— .05	—	5.07	183	9.7	127
.01	—	6.91	250	13.3	173

Experiment 2.—Five different insecticidal dusts and an untreated check were used in experiment 2, *viz.*, (1) calcium arsenate, (2) 50–50 calcium arsenate plus lime, (3) $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime, (4) 50–50 calcium arsenate plus sulfur, (5) $33\frac{1}{3}$–$66\frac{2}{3}$ barium fluosilicate plus talc. Table 2 gives a summary of the data obtained in this experiment.

According to table 2, if yield records are used as criteria for comparison, a highly significant value is shown favoring the untreated check over calcium arsenate or 50–50 calcium arsenate plus sulfur for boll weevil control. Likewise, if the boll-count criterion is used, no significance can be shown between either of these treatments and the untreated check, although the 50–50 calcium arsenate plus lime treatment appears significantly better than the check. These criteria did not show the relative value of the insecticides used for boll weevil control in this experiment, because a severe aphid infestation developed in the calcium arsenate and the 50–50 calcium arsenate plus sulfur plots, a heavy aphid infestation developed in the 50–50 and $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate

Table 2.—Summary of infestation counts, bloom counts, boll weevil counts, boll counts, yield records and insecticide applications, together with minimum differences required to give chances of 19 to 1 and 99 to 1, respectively.

Insecticide Used	Average Number of Pounds Insecticide Applied per Acre (Average of Nine Applications)	Average Seasonal Infestation per Plot, Per Cent	Total Number of Blooms per Plot	Total Number of Live Boll Weevils per Plot	Total Number of Bolls per Plot	Average Yield of Cotton per Plot, Pounds,
Calcium arsenate	8.19	15.72	2662	20.16	1424	79.83
1:2 Calcium arsenate plus lime	8.47	20.04	2436	18.16	1413	92.95
Check		32.80	1752	39.83	1401	91.58
1:1 Calcium arsenate plus lime	9.49	17.54	2643	22.00	1563	98.25
1:1 Calcium arsenate plus sulfur	11.36	17.50	2520	22.16	1321	78.58
1:2 Barium fluosillcate plus talc	12.18	28.88	1917	30.50	1381	88.83
Minimum difference between treatments required for a probability of— .05	—	4.86	193	11.02	130	8.40
.01	—	6.63	264	15.03	177	11.46

plus lime plots, a light aphid infestation developed in the barium fluosilicate plus talc plots and a corresponding degree of shedding occurred in each case. Therefore, these criteria are not reliable in determining the relative effectiveness for boll weevil control of the different insecticides that were used in this experiment.

In considering the comparisons of seasonal infestation and total blooms per plot, we find that calcium arsenate and each of its dilutions have a highly significant value over the untreated check according to both criteria. The $33\frac{1}{3}$–$66\frac{2}{3}$ barium fluosilicate plus talc is not significantly better than the check. A highly significant difference is shown favoring calcium arsenate and each of its dilutions over the barium fluosilicate plus talc mixture according to the seasonal infestation and bloom counts. Calcium arsenate shows a significance over $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime according to only one of these two criteria, the bloom counts; otherwise, no significance is shown between calcium arsenate and any of its dilutions.

DISCUSSION.—These two experiments were conducted in exactly the same way throughout the season. Both fields used were selected for the experiments because of the apparent uniformity of soil and cotton stand. The records were comparable for each type of data in each experiment. Calcium arsenate and its different dilutions with lime and sulfur were the only four treatments used in both of these experiments.

SUMMARY.—In these experiments calcium arsenate was superior to 50–50 or $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime for boll weevil control. There was no significant difference between calcium arsenate and 50–50 calcium arsenate plus sulfur for boll weevil control. The 10–90 pyrethrum plus sulfur and $33\frac{1}{3}$–$66\frac{2}{3}$ barium fluosilicate plus talc showed very little if any value as insecticides for boll weevil control. No significant difference was shown between 36 per cent cryolite and $33\frac{1}{3}$–$66\frac{2}{3}$ calcium arsenate plus lime for boll weevil control. Owing to the influence of aphids that often follow the application of arsenical insecticides, yield records may not be reliable criteria for determining the actual effect of an insecticide on the boll weevil. The need of an insecticide that does not increase the aphid infestation or that will control the aphids along with the boll weevil is clearly demonstrated in these experiments.—3-28-38.

A Progress Report on the Control of Boll Weevils on Sea-Island Cotton

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Because of marked differences in growth habits and boll susceptibility to weevil injury, the control of the boll weevil, *Anthonomus grandis* Boh., upon sea-island cotton differs considerably from control on upland or short-staple cotton. Modern upland strains, because of their determinate growth and fruiting habits, permit a short control campaign against the weevil with reasonable assurance that thereafter little or no injury to growing bolls will take place. A month to five weeks of protection are sufficient to assure the setting of a full crop at almost any time after squaring is in full progress. The long-staple sea-island cotton, on the other hand, has no flush squaring period, and neither its fruiting nor its vegetative habits are of the determinate type. The fruiting season is more prolonged, and the cotton continues growth and fruiting as it slowly matures the bolls set earlier in the season. Although it produces a reasonable quantity of blooms, sea-island cotton matures only a small quantity of them even under the best of conditions. After this cotton blooms, the rate of boll maturation is slow. Under conditions in southern Georgia, upland cotton will begin opening approximately 50 days after blooming, whereas sea-island cotton requires from 60 to 65 days before open bolls appear. Upland cotton blooming June 10 will usually begin opening by August 1 or a little earlier; sea-island cotton planted on the same date will bloom approximately June 15 and begin opening August 15 or later. The difference in blooming date is

due not so much to the slower growth of the plant to the squaring stage as it is to the slower maturing of the squares after they begin to form.

The upland square is subject to weevil attack for approximately 3 to 7 days before blooming, while sea-island squares are attractive to weevils for 6 to 10 days before blooming. The recent work of E. W. Dunnam has shown that bolls of upland varieties usually become sufficiently hard to escape weevil infestation in 10 to 20 days unless the weevils are very abundant and squares are scarce. Sea-island cotton bolls never become so tough as to make weevil oviposition impossible, and they are attractive and susceptible to injury until within a few days of opening. On sea-island cotton the weevils seem to exercise but little choice between squares and bolls for oviposition, but on upland cotton they show marked preference for squares.

The shorter period of susceptibility for fruit of upland cotton, which requires protection from boll weevil injury for only about a month, enables upland growers in many sections to disregard the weevils emerging from hibernation, and even a considerable fraction of the first brood, because by subsequent dusting they can reduce infestation so that the rapid fruiting plants will set sufficient bolls to make a crop in spite of the weevils. In other sections, such as the coastal plains of the Southeast, where fertility problems make early setting of the crop a necessity, control of the early weevils, hibernators and early first brood is often sufficient to permit a good crop to be produced. The slower square and boll development of sea-island cotton, on the other hand, makes it necessary to protect the individual squares and bolls during the entire period before the bolls are open, or from six to eight weeks. Furthermore, the crop is produced over a much longer period. The upland grower can set a crop in a week or 10 days in midseason, but the sea-island grower requires two to three times as long.

The revival of the industry in the old sea-island belt depends upon the solution of the boll weevil problem within the costs of profitable production. Yields of sea-island cotton are rarely over 200 pounds of lint per acre, and half this yield will probably come nearer the average in years of ordinary weevil damage. Fortunately, the higher value of sea-island lint makes it possible to employ more intensive and expensive control methods than can be used profitably on upland cotton in this section. With upland staple selling this year at about 8 cents per pound, sea-island sold for 23 to 24 cents per pound. Although the yields of sea-island cotton are less and the costs of production are considerably larger owing to the higher ginning costs and practically double picking costs, the value of the crop in southern Georgia last year averaged about $25 per acre as compared with $20 per acre for upland cotton. Some of the soils in southern Georgia and northern Florida are particularly adapted to the production of sea-island cotton and will produce as many pounds per acre as of upland cotton. The growth of sea-island cotton thus provides a much needed crop for a cash income in this section, even though the margin of profit may be small.

THE EXPERIMENTAL SET-UP.—A survey of the sea-island territory showed that very little boll weevil control was being practiced other than occasional presquare mopping. Many of the cotton growers, however, also produced tobacco and were well equipped with hand guns for dusting or with small traction outfits, drawn by a single animal, for spraying. Very few power machines, either dusters or sprayers, were found in the territory. In 1937, therefore, some experiments were designed to utilize the equipment available on the farms. A program was planned to include early-season poisoning with calcium arsenate dust, mopping throughout the season with a mixture of calcium arsenate, syrup and water, dusting with calcium arsenate and mixtures of calcium arsenate and sulfur or lime, and spraying with calcium arsenate. In addition the opportunity was given of observing the large-scale mopping program conducted in Florida and Georgia with funds provided by the WPA.

Work was conducted at Tifton and at Lake Park, Ga., in cooperation with the Georgia Coastal Plain Experiment Station; near Savannah, Ga., in cooperation with the State Entomologist of Georgia; and near Gainesville, Fla., in cooperation with the Florida Agricultural Experiment Station. The distribution of the work between the coastal plain and upper coastal

plain sections and around the edge of the marginal areas of the old sea-island belt gave considerable information on the effects of climatic conditions and the proximity of upland to sea-island cotton on weevil control.

Plots ranging in size from one-fortieth to one acre were used at Tifton and Savannah, Ga., and near Gainesville, Fla., while fields of several acres were used at Lake Park, Ga.

RESULTS OBTAINED.—Because 1937 was a year of a very light initial infestation, presquare applications were of no practical value. At no time before the last of July did square infestations in any of the fields average as much as 10 per cent, though occasional plots reached that figure. A relatively heavy population developed during August, particularly where the ripening of upland cotton caused migration of weevils to the sea-island cotton.

A detailed report on the 1937 work will not be presented at this time, and the results are to be considered as a preliminary progress report.

Mopping, which consisted in the use of the poisoned syrup-water mixture in the proportion of 1 to 1½ pounds of calcium arsenate, 1 gallon of cane syrup and 1 gallon of water, applied with a home-made mop, gave good control early in the season and was of value in reducing the first-brood weevils. It failed to protect against the late weevils, however, and, where it was the only control used, serious loss from injury to growing bolls occurred in many fields after mid-August. There was no indication of arsenical injury from this treatment.

The dusting experiments were divided into two series, one utilizing the standard method of dusting after 10 per cent infestation was reached, as used for upland cotton; and the other, intensive dusting and defoliation ranging from light injury at from 2.5 to 5 per cent infestation to keep the cotton fully protected at all times and prevent the infestation from building up. So far as weevil control was concerned, both methods proved satisfactory. Yields were somewhat larger on the plots given the intensive treatments, which received two or three additional applications, but the profits from the treatments were less. However, a heavy weevil infestation occurred only after August 1, and at no time after August 10 was the infestation reduced below 10 per cent; so the two treatments were almost identical in both series. Arsenical injury on some fields to severe injury on others occurred in the plots receiving the intensive treatments, and to a lesser degree on those dusted by the standard method. In none of these plots did the yields drop below those of the checks or of the sprayed plots.

Table 1.—Effect of different treatments on the control of the boll weevil on sea-island cotton, 1937.

TREATMENT	YIELD OF SEED COTTON, POUNDS PER ACRE			
	Gainesville, Fla.	Lake Park, Ga.	Tifton, Ga.	Savannah, Ga.
Dusting	428	441	455	442
Spraying	—	—	446	—
Mopping (throughout season)	—	404	414	328
Check (no treatment)	253	219	388	338

It is believed that an intensive dusting program may be necessary in years of heavy weevil infestation, though this opinion is not based on concrete evidence. The increase in yields from the plots treated with the dust mixtures of calcium arsenate and sulfur or lime was not quite so great as from the undiluted calcium arsenate.

A series of plots sprayed with 5 pounds of calcium arsenate, 1 gallon of cane syrup and 49 gallons of water, at the rate of 25 to 30 gallons per acre gave fair protection and sufficient increase in yields to make a small profit. A 10:50 mixture of calcium arsenate and water gave somewhat better control, but it was difficult to keep this quantity of calcium arsenate in suspension. Rather serious arsenical injury was also noticeable on the sprayed plots. The value of the spray method is not yet established and should be further investigated.

A brief summary of the increase in

yields obtained from the different types of treatment is shown in table 1.

CONCLUSIONS.—The results of the season's work are distinctly encouraging and are consistent in that the dusted plots and fields uniformly showed the best protection from late injury to bolls and the largest increases in yields. Under conditions as they existed in 1937, the boll weevil can be controlled on sea-island cotton. Sea-island cotton seems to be more susceptible to arsenical injury than upland cotton. This is a serious problem, as a prolonged poisoning schedule appears necessary for weevil control. The soils used for sea-island production are the light sandy types, seriously deficient in potash and nitrogen, which are more subject to arsenical injury than the heavier types. It was noted that where the land was well fertilized the use of arsenicals did not cause sufficient shedding of leaves to reduce the number or size of the bolls. It is hoped that a study of fertilizer needs and handling may prevent injury of this type and permit a heavy poisoning schedule without serious injury to foliage or bolls.—2-14-38.

Control of Insect Pests of Milled Rice by Improved Storage Bags

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Insects are especially destructive to rice after milling. At least four species that cannot penetrate the hulls in the rough will attack the rice grains after the hulls are removed. Added to these are at least four other species that ordinarily feed upon rough rice, but readily change to milled rice when possible. It may be observed, therefore, that the control of insects after milling is more important than before, as the number of species attacking rice is more than doubled by milling.

The milling of rice removes all insects and their eggs except the eggs of the rice weevil, *Sitophilus oryzae* (L.), which places its eggs so deeply in the grain that one occasionally escapes the polishing machinery. The percentage of insects surviving from this source is so small that little damage results if the rice is protected from outside infestation at the time of milling. The fact that a few insects pass through the milling process prevents a perfect control in milled rice, although such control would otherwise be relatively simple and economical.

STORAGE IN PAPER BAGS.—Tests with multiwall paper bags gave 80 per cent better control than the burlap bags commonly used for storage of milled rice. It was found, however, that small insects, such as the saw-toothed grain beetle, could crawl through the holes made in stitching. This necessitated finding some method of closing the bags without stitching.

A test to observe the efficiency of taped closures was conducted in which were used 12 small three-ply bags with 10 pounds of milled rice in each bag. These bags were filled on August 15, 1936, and the rice remained in the bags until June 17, 1937, when it was examined. The bags were stitched on an ordinary sewing machine, and the seams, including the corner folds, taped with heavy gummed paper. The bags were stored in a rat-proof room with rough rice, which was badly infested. The rice in this test was heated to about 140 degrees F. before being put in the bags, and held at that temperature for eight hours, so that all insects or eggs would be killed. The bags were opened after being stored 10 months, and the condition of the grain was observed. It was found that none of the bags had been entered by insects, with the exception of one bag, which had been penetrated by termites after they had burrowed through the floor of the room. This lot was checked against other untaped lots not in the same room but where infestation possibilities were no greater and insects were present in all bags. The rice was bright and in good condition in all other taped bags.

It was apparent that the extra cost of taping the seams would be prohibitive un-

less a machine could be designed to apply the tape at the time of stitching. This appeared to be impractical. It was noted that a machine could not tape the inner-side folds, made to allow expansion of the bag after it is filled, where the stitching crosses the ends over the folds.

CLOSING THE BAGS WITH METAL STRIPS.—It was found that these bags could be closed firmly by applying a metal strip crimped in a U- or V-shaped fold and slipped over the end. The strip reaches the entire width of the bag and is pressed down tightly with four or five rivets or clinchers inserted through the strip to prevent slipping. The rivets or clinchers can be omitted if the metal used is thick enough to resist strain.

A test comparing burlap and paper bags closed by metal strips was made. Rice, after having been fumigated, was put into 25-pound bags, stitched at the bottom. Some of these bags were three-ply, others five-ply. Seventeen paper bags and three small burlap bags, made from the burlap ordinarily used in packing rice, were used in the test, making 20 bags in all. Metal strips were applied to the bottoms of the paper bags to hide the stitches and the tops were closed with metal strips. The burlap bags served as checks.

This test was begun April 14 and concluded December 6, 1937. The interval of nearly eight months covered the time of year of the greatest insect activity; in fact, practically the entire period of activity.

Examination at the close of the period showed that no insects had entered the paper bags, except termites, which had punctured three bags, although plenty of insects were present on the outside of the bags and had entered the burlap bags used as checks.

Paper bags have some advantages over those made of burlap or cotton, other than protection from insects. Rice stored in paper bags retains its moisture, thus preventing loss of weight, which may be as much as two pounds per pocket in some instances. It also keeps the bright luster or fresh appearance which adds to the market value.

The metal closer has an advantage over tape in that no stitches are required to close the bag, and it makes the bag more nearly airtight than does stitching. It has the added advantage that it may be applied by a machine, which may be designed, that will clamp and clinch with the same action of a foot or hand lever, thus speeding the closure even beyond the time required to stitch a bag. This method of closure should cost little, if any, more than stitching.—10-1-38.

Some New Notes on the Sugarcane Rootstock Weevil, *Anacentrinus subnudus* Buch.

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The sugarcane rootstock weevil, *Anacentrinus subnudus* Buch., has been known to be present in the surgarcane section of Louisiana since April 29, 1910, when it was first found at Berwick, La., by D. L. Van Dine (Holloway 1912a; Holloway 1912b). From time to time, it has been reported as a pest of sugarcane (Ingram & Holloway, 1930), but the damage apparently was of minor importance until June, 1931 (Hinds & Osterberger 1932). At this time, the infestation in one 100-acre field of first stubble P.O.J. 213 cane in the Arnaudville section was so serious that the stand was almost completely destroyed.

Such a serious infestation necessitated making some observations on this weevil. It was learned that it had not been described (Buchanan 1932), which meant that information about its habits was lacking. Such information was needed before any control work could be begun.

Information was collected on cultivated and wild host plants. Eggs were found and the life history of the weevil was studied. In the early part of 1936, it became apparent that if these studies were to be satisfactory, it was necessary to make this a station project, so that a more systematic study could be made of this weevil and its control.

HOST PLANTS* IN LOUISIANA.—The recorded host plants, in addition to sugarcane, corn and sorghum, are *Paspalum boscianum* (bull grass), *P. urvellei* (vasey grass), *P. dilatatum* (dallis grass), *P. laeve*, *Eleusine indica*, *Panicum dichotomiflorum*, *P. gymnocarpon*, *Echinochloa walteri*, *E. colonum* and *E. crusgalli*.

This weevil has been found throughout the cane section of Louisiana, and especially in abundance in *Paspalum urvellei*, which seems to be the preferred host plant.

METHODS OF STUDY.—The adult weevils were first collected from stubbles of sugarcane, but it was found that collections could be made by submerging roots of *Paspalum urvellei* (vasey grass) in a container of water. The adult weevils floated to the surface of the water and were easily collected. From 1 to 20 pairs of weevils were then placed in cloth covered cages made of quart cans one-fourth full of finely sifted soil with a small section of sugarcane placed in each cage for food and for oviposition.

The food materials were removed daily and carefully examined under the binocular for eggs, which were placed in small sterilized boxes three-fourths filled with sterilized building sand which had moisture added nearly to the point of saturation. A piece of paper toweling, cut to fit the box, was placed on the moist sand, and the eggs were put on this paper. As soon as the eggs hatched, the young larvae were transferred to young sugarcane plants and set out in the following manner. Non-infested C.P. 29–320 cane, ranging from 2 to 3 feet in height, was dug and carefully washed free of all soil particles. A small cavity was made in the rootstock with a dissecting needle, and newly hatched larvae were placed in the cavity. The inoculated stalks were than reset in a specially prepared bed, made by placing 1-gallon cans with perforated bottoms 3 feet apart in the soil. These cans were regularly filled with water; this prevented the seedbed from drying out, and also prevented the flooding of the plants from the surface.

These inoculated plants were taken up at intervals for observation. The prepupae were removed and placed in the same type of cage that was used for the egg incubation period, for study of the pupation period. As the adults emerged, they were mated and placed in the mating cages for observation on preoviposition, oviposition and postoviposition, length of life and number of eggs deposited.

LIFE HISTORY.—The egg of the sugarcane rootstock weevil is creamy white in color and oval in shape. The average measurements are 4 millimeters in diameter by 6 millimeters in length. The eggs are deposited singly in small punctures made by the beak in the rootstock and are completely concealed. At Baton Rouge, under field conditions, the weevil deposits eggs throughout the year. Under cage conditions, and subject to outside climatic conditions, it was possible to collect eggs the year around. The rate of oviposition was greater during the warm season than at any other time of year.

Incubation records were kept the entire year. These have been divided into two periods to show the effects of temperature on the length of incubation period, and are summarized in table 1.

Table 1.—Length of incubation period of eggs of the sugarcane rootstock weevil.

PERIOD OF INCUBATION	MAXIMUM DAYS	MINIMUM DAYS	AVERAGE DAYS
October 1, 1936, to April 1, 1937*	30	7	20.0
April 1, 1937, to Sept. 1, 1937**	16	4	6.3

* 72 eggs observed.
** 283 eggs observed.

THE LARVA.—A newly hatched larva is white, has a brown head and measures about 1 millimeter in length. Much damage is done to the rootstock and small roots by this stage which feeds on and tunnels the rootstock. A full grown larva measures about 5 millimeters and as many as 23 have been found in an 8-inch piece of P.O.J. 213 rootstock. A complete record was kept on 70 individual larvae under insectary conditions from April to September, 1937, and it was found that the larval period varied from a minimum of 22 days to a maximum of 39 days, with an average of 27 days.

THE PUPA.—Pupation takes place within the rootstock in a special cavity near the surface. From a study of 48 individuals, May to September, 1937, it

* Identifications of plants checked by Drs. C. A. Brown and E. M. West of the Department of Botany, Louisiana State University.

was found that the maximum number of days of the pupal stage was 13 days, with a minimum of 8 days and an average of 9.4 days.

THE ADULT.—Study of the adult was made from May to September, 1937, and a total of 43 mated pairs was carried until natural death ended the series. It was found that the longevity of the males was from 18 to 72 days, with an average of 49 days, while the females' longevity was from 15 to 57 days, with an average of 45 days, in which time a total of 11 to 24 eggs, with an average of 16 eggs per female, was deposited.

HABITS OF THE ADULT.—In heavily infested fields, the weevils were found on the surface of the ground, among dried leaves and debris about the base of the plant, in the soil and up on the stalks, 3 or 4 inches from the ground, as well as in the cane rootstocks. The natural habitat seems to be near the base of the plant in the loose leaves and soil and around the rootstock, where the weevil may be found feeding on young shoots, eyes (buds) and on the rootstock. Injury by adults is noticeable but not so serious as that done by the larvae. Attempts to catch weevils on tanglefoot screens have not been successful, but a few have been observed flying under laboratory conditions.

Weevils, when disturbed, remain motionless and feign death for several seconds. They may secure partial protection from their subterranean habit, small size and soil-like color.

SUMMARY.—The rootstock weevil is capable of seriously injuring stands of sugarcane in both plant and stubble crops under Louisiana conditions.

It has been found abundant in south Louisiana, feeding on sugarcane, corn sorghum and nine wild host plants of *Paspalum* family. From biology studies it was found that activity is continuous with the life cycle as short as 43 days during warm months, and extending over a rather long period during cold weather.—2-18-38.

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A Study of the Decrease in Effectiveness of Cubé When Exposed to Weathering

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The value of a material having insecticidal properties is greatly enhanced by its ability to remain toxic for a period of time after being applied to plants in the field. It is often improved by combination with other materials, nontoxic themselves, which have the property of adhering to the foliage longer (stickers) or of giving a better distribution of the insecticide over the foliage (spreaders).

The use of rotenone-containing materials in the control of insects infesting cabbage has been handicapped by a lack of knowledge of the length of time these materials remained toxic after application and the effect of weathering upon this toxicity.

In the studies presented herein, cubé, the most available of the rotenone-containing plant materials, has been applied as a dust with various diluents and as a spray with different spreading or adhering agents to field-grown cabbage in an effort to determine for given lengths of time the decrease in effectiveness of such combinations in killing larvae of the imported cabbage worm, *Pieris rapae* (L.). These tests were conducted at the Sanford, Fla.,

laboratory of the Bureau of Entomology and Plant Quarantine during the period January 5 to March 24, 1937. The materials were applied to small plots in the field in a manner similar to the way a grower would apply them. On the first third and fifth days after applications, five random leaves were taken from each plot and placed singly in Petri dishes, each of which contained three uniform quarter-grown larvae of the imported cabbage worm. By this method the materials were applied to growing plants and exposed to all kinds of weather, whereas the relative effectiveness over given periods of time was tested under controlled laboratory conditions. The most difficult part of this procedure was to have a sufficient supply of uniform larvae on hand to complete a test. Several tests were discontinued owing to lack of proper larvae for the last sampling.

These tests were all conducted within quarter-acre blocks of thrifty cabbage, each material being applied to a single row 25 feet in length. No barrier rows were used or other provisions made to prevent drift of insecticides, as preliminary tests had indicated that such provisions required more labor than was warranted by any increased efficiency of the test. Some of the tests were made on young cabbage, others on cabbage starting to head and others on headed, mature cabbage. In all cases the samples for biological testing were taken from exposed leaves which were certain to have been well covered with the insecticide.

No samples of the foliage were taken immediately after the applications because laboratory tests had shown that such foliage treated with a 0.5 per cent rotenone dust was so toxic to cabbage worm larvae that total mortality could be expected. Samples were therefore taken on the first, third and fifth mornings after treatment. Thus, the materials were exposed to four periods of daylight and five periods of darkness. Notes were made of rainfall, dew, direction and approximate velocity of wind, and approximate amount of sunshine.

MATERIALS.—The source of rotenone in the first six tests (nos. I–VI) was a sample of powdered cubé root containing 6.0 per cent rotenone and 20.5 per cent total carbon tetrachloride extractives, while that in the last two tests (nos. VII and VIII) was a different sample of powdered cubé root containing 6.9 per cent rotenone and only 15.9 per cent total carbon tetrachloride extractives.

Four of the treatments in each test were applied as sprays and four as dusts, with one untreated control. The dusts were always mixed in the proportion of 1 part of cubé to 9 parts of diluent. The diluents were talc, clay, tobacco dust and sulphur, which were purchased from local distributors. The sprays were made up to contain 2 pounds of cubé per 50 gallons of water, and the adherent or spreading agents added at the rate of 1 part in 800 or 1 part in 500, the quantity being kept constant in any one test. The proprietary spreaders or adherents used in these spray tests were (1) a sulphonated partly oxidized petroleum hydrocarbon, (2) alkylphenylbenzenesulfonic acid and (3) calcium caseinate.

APPLICATIONS.—Dusts were applied with a small rotary hand gun, calibrated so that approximately 15 to 20 pounds per acre were applied. Sprays were applied with a hand sprayer delivering a fine-spreading spray. With small cabbage the dusts were applied only once, directly over the buds, but with larger plants two applications were made by directing the dust cloud at an oblique angle toward the outer sides of the plants in the row. Sprays were all applied three times over the plants, once directly down into the bud and once low on each side, in the attempt to cover all the leaves.

The machines were calibrated prior to application and outside the experimental areas by making repeated trials with known weights of materials for measured distances. The amounts used on the treated plots were also often recorded. In all cases where complete data on the amounts of material applied were taken it was found that more actual cubé per acre was applied by the dusts than by the sprays but that the sprays appeared to give better coverage.

RESULTS.—Two distinct classes of results were obtained, (1) the usual comparison of the effects of deliberate experimental treatments and (2) the comparison of the effects of different weathering conditions that occurred naturally from test to test. These results are summarized separately in tables 1 and 2, respectively.

Table 1.—Mortality of imported cabbage worm larvae by materials and samplings.

SAMPLING	A	C	B	CLAY	WATER	TOBACCO	SULPHUR	TALC	CONTROLS
1st	114†	110	109	108	103	102	101	105	18
2nd	88	84	82	69	65	67	61	48	23
3rd	59	61	58	47	53	48	33	40	21
Material totals	*261*	*255*	*249*	*224*	*221*	*217*	*195*	*193*	*62*

Difference required for significance with odds of 19 to 1:
Between samples of any materials = 22
Between material totals = 38
† 120 larvae were used in each instance.

The interpretation of these data is complicated by the fact that one of the chief objectives was to study the effect of varying weather conditions which constitute a large part of the usual experimental error. Thus the analysis of variance (Fisher & Wishart 1930) as shown in table 3 is composed of three parts. The usual analysis was first made in order to separate and measure the variances due to treatment and to error. Each of these was then further broken down into as many component parts as the experimental design provided.

Table 2.—Mortality of imported cabbage worm larvae by tests and samplings.

	TEST NO.								
SAMPLING	VII	II	III	VIII	I	VI	IV	V	SAMPLING TOTALS
1st	118†	92	105	120	100	116	97	104	852
2nd	120	83	71*	56*	86*	42*	74	32*	564
3rd	110	69	50	41	29	46	11*	43*	399
Test totals	*348*	*244*	*226*	*217*	*215*	*204*	*182*	*179*	
Rainfall:	trace	trace	0.03	2.20	0.03	0.05	0.80	0.20 0.60	

Difference required for significance with odds of 19 to 1:
Between samplings in any test = 22
Between test totals = 40
Between sampling totals = 61
* When the rain fell.
† 120 larvae were used in each instance.

Effect of Treatments.—There are two kinds of treatments, namely, the nine

Table 3.—Analysis of variance of mortalities of imported cabbage worm larvae.

VARIATION DUE TO—	SUM OF SQUARES	DEGREES OF FREEDOM	VARIANCE
Total (classes of 3 Petri dishes each):	5,056.218	215	—
(1) Between tests (time replicates)	772.144	7	110.306*
(2) Between treatments (including controls)	2,909.510	24	121.230*
(3) Remainder (total error)	1,374.564	184	7.470
Treatments:			
(2a) Between materials (including controls)	1,204.676	8	150.584*
(2b) Between samplings (excluding controls)	1,642.594	2	821.297*
(2c) Interaction "materials×samplings"	62.239	14	4.446
Analysis of remainder (error for main comparisons):			
(3a) Interaction "tests×materials"	247.672	49	5.054†
(3b) Interaction "tests×samplings"	688.906	14	49.208*
(3c) Interaction "tests×materials×samplings"	295.594	98	3.016‡
(3d) Effect of controls upon variation between tests without changing degrees of freedom	62.559	none	—
(3e) Gross variation between controls	79.833	23	3.471

* Highly significant.
† Significant.
‡ Used to test significance of interactions "tests × materials" and "tests × samplings" only.

different insecticide materials, including the controls, and the three different samplings. The highly significant variances noted in table 3 show that each kind of treatment gave definite results that cannot be accounted for by experimental error. The relative mortality decreased rapidly as 852 larvae out of 960 (89 per cent) were killed on samples taken after one day, 564 out of 960 (59 per cent) after three days and only 399 out of 960 (42 per cent) after five days. Although this deterioration is very pronounced, it will be noted that about 42 per cent of the 960 larvae were killed on treated leaves that were exposed to ordinary weather conditions for five days before being used as food, whereas there was only 17 per cent mortality on the untreated leaves, indicating that, on the average, there was still toxic material remaining on the plants after five days' exposure to weathering.

When the data by treatment totals is summarized, it is evident that the sprays containing spreaders and adherents gave the highest mortality and that sprays were superior to dusts, probably owing to the better spreading and covering properties of the sprays. There were no significant differences between the spreaders in the sprays or between the diluents in the dusts.

The lack of a significant variance for the interaction "materials×samplings" proves that the rate of decrease in mortality from sampling to sampling was practically the same for all materials whether sprays or dusts and regardless of the type of inert material used as adherent, spreader or diluent. This is interpreted to mean that the weathering that caused the decrease in mortality from sample to sample acted upon the cubé regardless of the presence of adherents or other materials. This indicates that the superior mortalities obtained with sprays with certain adherents or spreaders were due to something other than resistance to weathering. In other words, these materials were superior from the beginning, owing probably to more adequate coverage.

Effect of Different Weather Conditions.—The pooled effect of different weather conditions and broods upon the mortalities as a whole is manifested in the results for different tests because the latter were conducted on different dates and subjected to exposures of varying amounts of precipitation, sunshine and wind. Under such diverse conditions it was only natural that the variance for "between tests" should be highly significant. This is a desirable condition, but the detailed differences in tests are not nearly so important as the manner in which the weather factors associated with them influenced the relative mortalities due to the materials and rates of decrease in effectiveness. These are measured by the interaction variances. Table 2 shows the variation between tests as a whole.

In test VII, with a mortality of 348 out of a possible 360 (96.7 per cent), the results were distinctly better than in any of the other tests, while in test II, with a mortality of 244 out of 360 (67.8 per cent), they were better than in tests IV, V and VI. These two tests VII and II were the only ones that were exposed to less than 0.01 inch of precipitation, indicating that the presence or absence of precipitation is an important factor. However, the amount of precipitation after reaching a very low minimum seemed to be of much less importance, as test VIII, which was exposed to 2.2 inches precipitation, gave approximately the same mortality as did tests exposed to as low as 0.03 inch. It is quite likely that a variation in the susceptibility of the broods was partly responsible for these general differences between tests, but the limited number of controls used failed to substantiate this.

The significant interaction of tests × materials proves that the effect different tests had upon the mortality varied among the materials; in other words, something besides chance caused different materials to appear superior in the several tests. The logical explanation may at first seem to be that certain adherents had been more effective in resisting rainfall than had others, but this theory fails because it has already been shown that the decrease in effectiveness of all the materials was the same. Weathering could not have caused this unless in some manner that affected the first samplings within less than 24 hours. Upon careful study of the conditions existing during the experiment, it became evident that the explanation lay not in weathering but in the varied amount of materials applied despite the careful calibration of the machines prior to application.

The fact that the interaction tests × samplings was highly significant proved that some condition associated with only certain tests caused the effectiveness of the cubé in all treatments to decrease as the time of exposure to weathering increased. The general notes made on the prevailing weather conditions during the individual tests were studied in an attempt to discover just what factors other as much rainfall would be necessary to decrease the mortality a further 18 per cent.

The small variance for the triple interaction of tests × materials × samplings demonstrates that the effectiveness of the several mixtures of cubé decreased from sampling to sampling at a uniform rate; that is, none of the inert ingredients used was successful in preventing these effects of weathering.

Table 4.—Decrease in mortality during four days' exposure as affected by precipitation.

	Test No.							
	VII	II	III	V	VI	I	VIII	IV
Decrease in mortality	8	23	55	61	70	71	79	86
Logarithm of (100 × inches precipitation)	0.000	0.000	0.477	1.903	0.699	0.477	2.342	1.903

than length of exposure seemed to be most closely associated with these decreases in mortality. It was difficult to see much evidence of the influence of sunshine or wind, other than the general effect upon all tests alike, and unfortunately the records on these factors were not made with sufficient detail to permit mathematical studies. The effect of precipitation was more notable, as small amounts were accompanied by considerable decreases in mortality. This effect seemed to diminish as the total rainfall increased, indicating a curvilinear relationship of a logarithmic nature, as was substantiated by correlation studies. The logarithms of the total rainfall over four-day periods of exposure are given in table 4 with accompanying decreases in mortalities.

For this purpose a trace of precipitation which is actually less than one one-hundredth inch was considered as one one-hundredth inch. This assumed value is conservative, as lower values would give a higher correlation than is here indicated. There was a significant correlation ($r = 0.74$) between the decrease in mortality and the logarithm of rainfall. The coefficient of determination was 0.54, showing that the variation in rainfall accounted for approximately 54 per cent of the variation in decrease in mortality and that the remaining 46 per cent was caused by other factors. The regression coefficient was 22 ± 8.1, indicating that a tenfold increase in the amount of rainfall above one one-hundredth inch would tend to decrease the mortality by an average of 22 ± 8 larvae, or 18 per cent, and that 10 times

SUMMARY.—Eight combinations of cubé were applied to cabbage in the field; and, after as many as five days of exposure to weathering, samples were fed to imported cabbage worms under controlled laboratory conditions to obtain relative mortality records. Eight replicates of each of these tests were made under widely different weather conditions.

There was a uniform decrease in mortality for all combinations, but the cubé remaining after five days killed an average of 42 per cent of the test insects as compared to a 17 per cent mortality in the controls, indicating that, on the average, there was still toxic material remaining after five days of exposure to weathering.

Spray suspensions of cubé with adherents and spreaders gave a greater total mortality over a period of five days than did dusts with four different diluents. However, the kind of spreader or the kind of diluent made no appreciable difference, indicating that the choice of either could be based on availability and price. Although the water suspension without adherents or spreaders utilized only about half as much cubé to the acre as did the dusts, it gave equally good mortalities.

Precipitation was second to duration of exposure in causing decreases in the effectiveness of cubé dusts and sprays. This was indicated by a significant correlation ($r = 0.74$) between the decrease in mortality during four-day periods of exposure and the logarithms of the total precipitation recorded during these respective periods.—6-13-38.

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Laboratory Tests With Insecticides Against the Vegetable Weevil

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During the early part of 1937 a series of laboratory experiments was conducted with a number of insecticides to determine the relative effectiveness of these materials as compared with a known standard arsenical against the vegetable weevil, *Listroderes obliquus* Klug. Insecticides in dust, liquid and bait forms were tested against larvae or adults.

The specimens used were reared in the insectary or collected in the field and were classified as to age and size. Larvae were listed as small, medium small, medium large, and large, these terms indicating less than one-fourth grown, one-fourth to one-half grown, one-half to three-fourths grown, and three-fourths to full grown, respectively. All adults were young and recently emerged, but had fed regularly for several days prior to the beginning of the experiments.

METHODS AND PROCEDURE.—For the application of the dust mixtures and liquids a shoulder-type compressed-air tank, equipped with a constant-pressure valve and gauge, was used as a reservoir for supplying pressure, and for permitting an even pressure while the insecticides were applied. A large glass bell jar was used for a treatment chamber for the dust applications and 3 grams of dust under 3 pounds pressure were discharged into the chamber from below and allowed to settle for 45 seconds. The same process was used for the application of the liquids, except that a hand paint sprayer was used and the spray fog was directed into a specially constructed box, under 15 pounds pressure for 25 seconds.

The insects were handled with moist camel's-hair brushes, and Petri dishes were used for cages; equal quantities of turnip leaves and baits were used in all tests. The insects were transferred directly to the treated surface of the leaf, or when contact poisons were used the larvae were placed in the Petri dishes and exposed to the insecticides, and untreated food was introduced into the cages afterwards. Only one surface, upper or lower, of the leaves was treated. The specimens were examined daily for four days and judged to be dead or alive according to the observation of the fourth day.

Ninety insects were used in each experiment; 15 were selected for each application according to size or age and 5 were placed in each of three Petri dishes. With this arrangement six replications were obtained with each material.

INSECTICIDES TESTED.—The following materials were used against the larvae: derris dust diluted with china clay (no. 3) to contain 0.5 per cent, 1 per cent and 2 per cent of rotenone; pyrethrum, containing 1.05 per cent of total pyrethrins, diluted with equal amount by weight of china clay (no. 3); sulfur, undiluted; derris powder in water, diluted to contain 0.025 per cent of rotenone, without a wetting and spreading agent; derris powder in water, diluted to contain 0.025 per cent of rotenone, plus a proprietary alkylphenylbenzenesulfonic acid 1–600 as a wetting and spreading agent; phenothiazine in water, 2 pounds to 50 gallons; calcium arsenate, undiluted. The following materials were tested against the adults: pyrethrum and clay, equal amounts by weight; derris dust mixtures containing 1 per cent and 2 per cent of rotenone, with clay as the diluent; calcium arsenate undiluted; and baits prepared as follows:

Formula 1:	
Sodium fluoride	1 pound
Wheat bran	15 pounds
Finely chopped turnips	8 pounds
Water	to moisten
Formula 2:	
White arsenic	1 pound
Wheat bran	15 pounds
Finely chopped turnips	8 pounds
Water	to moisten

The results of the tests of insecticides against the larvae are given in table 1 and results of tests against the adults in table 2.

upon turnip leaves treated with derris dust mixtures, but later did not feed normally. Calcium arsenate killed the larvae more rapidly than did the other

Table 1.—Mortality among vegetable weevil larvae four days after treatment with various insecticides.

Material Used	Size of Larvae	Dead	Alive	Per Cent Mortality
Sulfur, undiluted	Small	36	9	80.00
Sulfur, undiluted	Large	7	38	15.55
Pyrethrum-clay, equal amounts	Small	45	0	100.00
Pyrethrum-clay, equal amounts	Large	37	8	82.22
Derris dust, 0.5% rotenone	Small	9	36	20.00
Derris dust, 0.5% rotenone	Large	2	43	4.44
Derris dust, 1% rotenone	Small	20	25	44.44
Derris dust, 1% rotenone	Large	10	35	22.22
Derris dust, 2% rotenone	Small	37	8	82.22
Derris dust, 2% rotenone	Large	10	35	22.22
Calcium arsenate, undiluted	Small	45	0	100.00
Calcium arsenate, undiluted	Large	40	5	88.88
Derris spray, 0.025% rotenone in water	Medium small, large	1	44	2.22
Derris spray, 0.025% rotenone in water	Large	14	31	31.11
Derris spray, 0.025% rotenone in water, plus wetter and spreader 1-600	Small, medium small, large	5	40	11.11
Derris spray, 0.025% rotenone in water, plus wetter and spreader 1-600	Medium small, medium large, large	5	40	11.11
Phenothiazine, 2 lbs. to 50 gal. water	Medium small, large	1	44	2.22
Phenothiazine, 2 lbs. to 50 gal. water	Medium small, medium large, large	1	44	2.22

Table 2.—Mortality among vegetable weevil adults four days after treatment with various insecticides.

Material Used	Dead	Alive	Per Cent Mortality
Pyrethrum-clay, equal amounts	41	49	45.55
Derris dust, 1% rotenone	6	84	6.66
Derris dust, 2% rotenone	22	68	24.44
Calcium arsenate, undiluted	90	0	100.00
Sodium fluoride bait	86	4	95.55
White arsenic bait	68	22	75.55

Reaction of Weevils After Treatment.—The pyrethrum and clay dust mixture caused an immediate paralysis in the larvae. No feeding occurred after treatment. The larvae remained practically motionless and exuded large quantities of moisture, and none recovered. Larvae fed to some extent when treated with other materials, although young larvae fed very little in the sulfur experiments. The larvae began feeding promptly

materials, but did not protect the food so readily or so completely as did the pyrethrum and clay dust mixture. Higher mortality occurred among young larvae than among older, more mature specimens.

Adults were paralyzed within a few minutes after treatment with the pyrethrum and clay dust mixture, and no feeding occurred for a week. Some weevils regurgitated the stomach contents freely.

Adults on the leaves given the derris spray treatments fed slightly and many of them acted as if paralyzed. Calcium arsenate caused mortality after but little feeding by the weevils. Adults fed readily upon both the sodium fluoride and crude arsenic baits and fed more freely upon the particles of wheat bran than upon the chopped turnips. Apparently neither of these repelled the adults and a satisfactory mortality was obtained with the bait containing sodium fluoride.

OBSERVATIONS IN THE FIELD.—In field experiments against the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis), on turnips and mustard by Harrison (1937) at Baton Rouge, La., it was shown that dust mixtures containing 1 per cent of rotenone, with equal parts of finely ground dusting sulfur and tobacco as the diluent, and derris sprays containing approximately 0.02 per cent of rotenone, with or without a proprietary alkylphenylbenzenesulfonic acid (1–1000) as a wetting and spreading agent, were effective in protecting the turnips and mustard from damage by larvae of *Listroderes obliquus* Klug. The check plots and also the plots that received applications of sprays or dust mixtures containing nicotine sulfate were badly injured by the weevil larvae. The insecticide applications were begun when the plants were small. The turnips received six treatments at 14-day intervals, whereas one set of mustard plots received four treatments at 14-day intervals, and another set received five treatments at 6- to 11-day intervals. Apparently in this series of tests the repeated applications kept the plants covered with the insecticide practically all the time and the young larvae were consequently exposed to insecticide soon after hatching.

SUMMARY.—There was no significant difference in toxicity between the pyrethrum and clay dust mixture and calcium arsenate dust in experiments against larvae of the vegetable weevil. Calcium arsenate was, however, more effective against the adults. These two materials were superior to all the other insecticides applied against the larvae. Sulfur, undiluted, and derris dust mixture containing 2 per cent of rotenone were effective against young larvae, sulfur causing 80 per cent mortality and the dust mixture of 2 per cent rotenone causing 82.22 per cent mortality. The 1 per cent rotenone dust mixture killed 44.44 per cent of the small larvae. The dust mixture containing 0.5 per cent of rotenone, the derris spray containing 0.025 per cent of rotenone in water, with or without a spreader, and the spray containing 2 pounds of phenothiazine to 50 gallons of water were not effective against the larvae. Sodium fluoride bait was practically as toxic as calcium arsenate dust against vegetable weevil adults, and crude arsenic bait was next in effectiveness.

Preliminary field experiments in Louisiana indicated that rotenone compounds may be effective against vegetable weevil larvae if applied at frequent intervals to plants infested with small larvae.—2-18-38.

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Observations on Cabbage Worm Populations at Baton Rouge, La.

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Cabbage, cauliflower, broccoli and several other botanically related plants are crops of major commercial importance in many localities throughout the United States. Several species of lepidopterous larvae are serious pests of these crops and have to be combated with insecticidal treatments. Previous investigations have shown that the different species which attack these crops react differently toward different insecticides. Therefore, since a knowledge of the seasonal abun-

* In cooperation with the Louisiana Agricultural Experiment Station.

dance of the different species is a valuable aid in the selection of the proper insecticides in formulating a control program, the information presented in this paper is believed to be of practical value.

During the fall of 1932 a study of cabbage worms was inaugurated by the Bureau of Entomology and Plant Quarantine and was made the major activity at the truck crop insect laboratory located at Baton Rouge. The phases of the activity that received early attention included a study of the limitations in the use of arsenicals on cabbage grown in the South (Smith *et al.* 1937) and a study of materials that could be substituted for or used in conjunction with arsenicals and fluorine compounds in combating cabbage worms, without leaving objectionable insecticidal residues, particularly those that are hazardous to the consumer.

In these early studies it was found that the adult females preferred certain plants upon which to oviposit. These plants were of the same age, size, variety and general appearance as those not preferred. After those plants first selected were severely injured by larval feeding, however, they became less attractive than those previously not so attractive to the females.

With the foregoing observations as a background, an intensive survey of conditions relating to cabbage and cabbage worms was begun in the fall of 1935 and continued through 1936 and 1937. Up to the present time a series of five experiments has been conducted. In the first four experiments the Copenhagen Market variety was used, while in the last one the Allhead Early variety was used. The physical set-up included five field replications in all cases except the fifth experiment, in which there were only two replications. A field replicate consisted of two blocks, which were taken at random, each containing four rows of 25 plants. Practically all of the cabbage included in this study was without insecticidal protection while the observations were in progress. The exception was a single field replication during the fall of 1936 which received three applications of a derris dust mixture containing 0.5 per cent of rotenone, but this failed to give satisfactory protection.

The data considered in this paper consist of the worm populations of the major species obtained by weekly examinations of plants in the last four survey experiments. The examinations were begun about one week after thinning on crops that were started by seeding directly in the field, and about two weeks after planting on those that were transplanted.

Although worms were recorded according to size or stage of development (except in experiment no. 1) and by species, only totals by species are considered in this paper. The data obtained from all field replicates by counts made within half-month periods are combined. This does not alter the picture of the situation materially, but some of the rather sharp increases and decreases which occurred are less apparent.

THE SPECIES INVOLVED.—The term "cabbage worms," as used in Louisiana, may refer to one or more species which infest cruciferous crops. The species most commonly present in damaging numbers, and also constituting the bulk of the population involved in these observations, were the cabbage looper, *Autographa brassicae* (Riley), the imported cabbage worm, *Pieris rapae* (L.), and the diamondback moth, *Plutella maculipennis* (Curt.). The other species included in the "cabbage worms" which infest and sometimes injure these crops are the cabbage webworm, *Hellula undalis* (F.), the crossstriped cabbage worm, *Evergestis rimosalis* (Guen.), and the southern cabbage worm, *Ascia protodice* (Bdv. & LeC.). Species not considered as "cabbage worms" which may infest and injure these crops are the corn ear worm, *Heliothis obsoleta* (F.), the granulate cutworm, *Feltia annexa* (Treit.), the black cutworm, *Agrotis ypsilon* (Rott.), one or two species of *Prodenia*, the fall armyworm, *Laphygma frugiperda* (S. & A.), and the salt-marsh caterpillar, *Estigmene acraea* (Drury). The greenhouse leaf tyer, *Phlyctaenia rubigalis* (Guen.), sometimes occurs on cabbage, but since it usually infests the older bottom leaves it causes little or no actual damage.

RESULTS.—A summary of the data obtained in this study is presented in table 1. The worms listed under Agrotinae include the corn ear worm, the granulate cutworm and the black cutworm. Other species mentioned above were not recorded, but merely observed. The data obtained in experiment no. 1 (fall of 1935) consisted

of counts of mature worms and pupae only; consequently they were not comparable with those of the other experiments and therefore were omitted from the table.

DISCUSSION.—As the data in table 1 indicate, the cabbage looper, the imported cabbage worm and the larvae of the diamondback moth constitute the major part of the worm population on cabbage at Baton Rouge, their relative importance being in the order named. The looper is predominantly the most important species on fall crops, and in some years, although not in the years reported here, it is very destructive on late maturing spring crops. The imported cabbage worm normally ranks first in importance, if not in numbers, on spring crops, while on fall crops it usually does not appear in injurious numbers until late in the season. The importance of the larvae of the diamondback moth appears to depend a great deal upon the nearness of the crop to the source of infestation and upon natural control agents. The species seems to spread rather slowly and thrives best during periods of dry, cool weather, especially when the temperatures are low enough to check the activity of its parasites but not sufficiently low to check its own activity.

Damage caused by the cabbage webworm is confined largely to the seedlings of fall cole crops. This species destroys the buds, thus rendering the plants worthless. The infestation during the fall of

Table 1.—Number of plant examinations and average number of cabbage worms, by species, per 100 cabbage plants for half-month periods, at Baton Rouge, La., 1936 and 1937.

PERIOD	NUMBER OF EXAMINATIONS	CABBAGE LOOPER	IMPORTED CABBAGE WORM	DIAMONDBACK MOTH	CABBAGE WEBWORM	CROSS-STRIPED CABBAGE WORM	AGROTINAE
1936			*Experiment No. 2*				
Mar. 1–15	1,000	—	0.70	—	—	—	0.10
16–31	2,396	0.46	16.57	15.44	—	—	0.25
Apr. 1–15	2,189	2.37	12.50	46.68	—	0.68	0.32
16–30	1,983	33.33	43.77	135.65	0.05	3.23	1.16
May 1–15	1,733	33.18	94.75	279.75	0.12	0.35	1.33
16–31	323	12.69	22.60	82.97	—	—	0.62
			Experiment No. 3				
Sept. 1–15	200	19.50	—	0.50	1.50	—	0.50
16–30	386	98.96	—	3.37	1.55	12.69	2.33
Oct. 1–15	1,360	142.65	5.59	2.50	4.04	3.60	0.66
16–31	2,139	136.14	8.14	6.83	12.86	4.30	2.11
Nov. 1–15	1,900	382.94	22.52	21.79	8.56	8.94	2.05
16–30	1,966	284.48	27.42	27.62	4.88	9.16	0.81
Dec. 1–15	1,728	199.31	43.52	39.12	1.91	0.23	0.47
16–31	829	43.40	34.19	31.78	1.05	0.05	0.05
1937							
Jan. 1–15	990	3.63	26.36	61.62	0.30	—	0.40
16–31	581	3.10	18.42	266.96	0.17	—	0.52
Feb. 1–15	236	18.62	51.81	596.19	—	—	0.42
			Experiment No. 4				
Mar. 16–31	1,600	—	10.81	2.50	—	0.06	0.06
Apr. 1–15	2,195	2.00	27.15	9.75	—	0.05	0.18
16–30	2,381	86.23	173.16	52.54	—	—	0.46
May 1–15	1,798	54.67	171.13	139.38	—	—	1.11
16–31	687	72.05	118.20	262.01	—	—	0.44
			Experiment No. 5				
Sept. 1–15	200	19.50	—	1.50	—	—	—
16–30	789	135.74	1.90	21.42	0.63	—	4.31
Oct. 1–15	978	238.75	18.10	33.99	0.20	0.72	16.16
16–31	781	972.60	61.08	180.41	0.64	4.99	10.88
Nov. 1–15	780	1,198.46	97.82	181.79	—	7.31	3.72
16–30	748	429.68	76.87	74.48	—	4.55	0.67
Dec. 1–15	757	130.65	135.14	124.70	—	2.77	0.13
16–31	593	14.17	78.41	336.09	—	0.34	—

1936 was about normal for this locality, while that in 1937 was below normal. The cross-striped cabbage worm is most abundant on fall cabbage and is seldom present in numbers sufficient to cause any appreciable damage. Owing to the moth's habit of laying its eggs in clusters, however, the infested plants are usually severely injured. Parasites are an important factor in keeping this species in check. As the data show, the Agrotinae are most abundant on fall crops. In addition to the losses caused by the cutworms in cutting off the young plants, the cutworms and the corn ear worm often attack the young plants when the heads are forming. Plants thus injured either produce poorly shaped heads, which are unmarketable, or the formation of heads may be prevented by the feeding of these worms.

SUMMARY.—The populations of cabbage worms recorded in four experiments conducted in a survey of conditions relating to cabbage and cabbage worms at Baton Rouge, La., during 1936, and 1937, are reported. It was found that the cabbage looper is the predominating species on fall crops and appears late on spring crops. The imported cabbage worm is the most important, if not the most abundant, species on spring crops and appears late on fall crops in damaging numbers. The diamondback moth ranks third in importance and may become abundant on either spring or fall crops. The cabbage webworm, the cross-striped cabbage worm and the several species of Agrotinae are most abundant on fall crops.—2-18-38.

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The Relative Insecticidal Effectiveness of Some Dusts Containing Rotenone

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The toxicity of rotenone-containing materials to most species of cabbage insects has been recognized for some time. Owing to conflicting reports on the comparative effectiveness of derris, *Derris elliptica* (Wall.) Benth., and cubé, *Lonchocarpus* sp., and the variation in chemical content of different samples of *Tephrosia* (*Cracca*) *virginiana* (L.) Pers., comparative biological tests have been made at the Sanford, Fla., laboratory in an attempt to answer the questions involved.

The materials used were samples of 1 pound or less received from the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

METHOD.—From previous experiments it was known that larvae of the imported cabbage worm, *Pieris rapae* (L.), were sufficiently susceptible to rotenone-containing materials to be used as test insects for comparisons of such materials.

The tests herein discussed were conducted as follows: Sections of food plants were sufficiently exposed in a settling dust chamber to receive approximately 0.3 milligrams of dust per square inch. After both surfaces had been thus treated, the food was transferred to a Petri dish in which 10 uniform larvae were introduced. After 24 hours those larvae still alive were transferred to untreated food for five days of further examination. The tests with each material were replicated 18 times, making a total of 180 larvae treated with each material. The total mortality for each material has been used as the basis of comparison.

COMPARISON OF CUBÉ AND DERRIS.—Three pairs of samples of powdered derris and cubé containing almost idential percentages of rotenone and total extractives were used for this comparison. All these powders were reported to have been ground to an equal fineness, and all represented the shipments as received except the derris of pair 3, which was a blend of

two powders. As will be seen in table 1, within each pair the rotenone content varied less than 0.4 per cent, and the total-extractives content varied less than 1.1 per cent, but between pairs the total-extractives content varied by as much as 6.0 per cent. These differences between pairs were believed to be sufficient to permit an indication of any relationship that might exist between the composition of the materials and the toxicity.

The materials were diluted, with clay, to contain 0.1 per cent of rotenone for the tests with the quarter-grown larvae and to contain 0.5 per cent of rotenone for those with the half-grown larvae. It was deemded desirable to have the rotenone content constant, as this is the chemical constituent usually used to standardize the dusts in field treatments.

Table 1 presents a summation of all the data. The mortalities were analyzed by the method of the analysis of variance (Snedecor 1934) to find the difference in mortality required to give minimum significance at odds of 19 to 1.

With the quarter-grown larvae there were no differences in the mortalities large enough to be significant except in the case of cubé in pair 1. The mortality for this sample was significantly lower than that for any of the other samples, indicating that it was definitely an inferior material, contrary to the chemical analyses. A comparison of the average mortality for the derris samples with that for the cubé samples did not show a significant difference.

With the half-grown larvae the relative effectiveness of each sample was practically the same as with the quarter-grown larvae, although the number of dead larvae was larger on account of the greater strengths of the samples. Here again the mortality with cubé of pair 1 was significantly lower than that with the best, but there were no significant differences between the samples in any pair. As with the quarter-grown larvae, there was again no significant difference between the average mortalities for the two materials.

Of the three pairs of materials having almost identical chemical analyses, the derris of pairs 1 and 3 tended to be better than the cubé, though significantly so in only one case, while the cubé of pair 2 showed a tendency to be better than the derris. The fact that differences in mortality were slight indicate that derris or cubé having similar chemical analyses could be used interchangeably.

COMPARISON OF DERRIS AND TEPHROSIA.—Preliminary tests had indicated that the undiluted *Tephrosia* powders were so toxic to the imported cabbage worm that dilutions were necessary before

Table 1.—Comparison of samples of derris and cubé as insecticides for larvae of the imported cabbage worm; 180 larvae used with each material tested (tests replicated 18 times with 10 larvae in each replication).

Pair No.	Material	Rotenone Content, Per Cent	Total-Extractives Content, Per Cent	Tests With Quarter-Grown Larvae			Tests With Half-Grown Larvae		
				Dilution Necessary to Give 0.1% Rotenone	Total Extractives After Dilution, Per Cent	Mortality, Per Cent	Dilution Necessary to Give 0.5% Rotenone	Total Extractives After Dilution, Per Cent	Mortality, Per Cent
1	Derris	4.00	20.9	1:39	0.522	86.11*	1:7	2.61	94.44†
	Cubé	4.10	21.9	1:40	0.517	76.11*	1:7.2	2.58	90.00†
2	Derris	4.90	16.3	1:48	0.332	86.11*	1:8.8	1.66	93.89†
	Cubé	4.70	15.9	1:46	0.338	90.56*	1:8.4	1.69	98.33†
3	Derris	6.30	20.9	1:62	0.333	93.33*	1:11.6	1.65	97.78†
	Cubé	6.00	21.0	1:59	0.350	87.78*	1:11	1.75	93.89†
Average, derris		*5.07*	*19.4*	*1:49.6*	*0.396*	*88.33†*	*1:9.1*	*1.97*	*95.00‡*
Average, cubé		*4.93*	*19.6*	*1:48.3*	*0.401*	*85.00†*	*1:8.8*	*2.01*	*93.89‡*

* Difference required for significance, 10 per cent, at odds of 19 to 1.
† Difference required for significance, 5.56 per cent, at odds of 19 to 1.
‡ Difference required for significance, 3.33 per cent, at odds of 19 to 1.

comparisons could be made. A mixture of 1 part of *Tephrosia* to 3 parts of clay was found to be most satisfactory. The samples of derris powder were dilutions containing 0.5 and 0.1 per cent of rotenone, respectively, made from a derris dust containing 9.2 per cent of rotenone and 22.8 per cent of total carbon tetrachloride extractives. Because of the high rotenone content of the derris these dusts contained a very high proportion of diluent, *viz.*, 17 and 89 parts of clay to 1 part of derris, respectively.

Table 2 presents the mortalities arranged according to the results with the more resistant half-grown larvae, together with the original total-extractives content of each sample, the dilution employed for these tests and the total-extractives content as used. The data were analyzed by the method of the analysis of variance, which showed that differences of 6 and 13 per cent were necessary to indicate significance at odds of 19 to 1 for the quarter-grown and half-grown larvae, respectively.

When the more susceptible quarter-grown larvae are considered first, the results show that there were no significant differences among the *Tephrosia* samples nor between any of these and the derris dust containing 0.5 per cent rotenone, but the derris dust containing 0.1 per cent rotenone was definitely inferior to all of the *Tephrosia* samples. However, the 1-to-3 dilutions used for the *Tephrosia* samples gave too nearly complete mortality to allow for making comparisons with larvae of this size.

With the more resistant half-grown larvae, however, the differences between samples were more pronounced. There was no difference between *Tephrosia* samples 399, 82 and 414, but sample 400 was inferior to the best, possibly because of the larger size of particles (coarser than 60 mesh). When compared with the derris dusts, *Tephrosia* samples 414 and 400 were definitely inferior to the derris having 0.5 per cent rotenone and were not superior to the derris having 0.1 per cent rotenone; sample 399 was not inferior to the derris having 0.5 per cent rotenone and sample 82 was barely inferior, but both of these better *Tephrosia* samples were superior to the derris containing 0.1 per cent rotenone.

Table 2.—Comparison of some samples of *Tephrosia* and derris as insecticides for larvae of the imported cabbage worm.

Material	Original Total-Extractives Content		Dilution for Test	Extractives Content at Test Strength		Per Cent Mortality Dead Larvae	
	Rotenone	Total		Rotenone	Total	Quarter Grown	Half Grown
Derris 0.5%	9.20	22.8	1:18	0.500	1.24	99.44	95.00
Tephrosia No. 399	0.39	5.4	1:3	0.097	1.35	95.00	84.44
Tephrosia No. 82	0.42	6.3	1:3	0.105	1.75	96.11	79.44
Tephrosia No. 414	0.17	6.0	1:3	0.042	1.50	98.33	71.67
Tephrosia No. 400*	0.27	4.4	1:3	0.067	1.10	96.67	68.33
Derris 0.1%	9.20	22.8	1:92	0.100	0.25	83.33	58.89
Difference required for significance at odds of 19 to 1:						*6.11*	*13.33*

* Sample 400 was coarser and sample 399 was finer than 60 mesh; the fineness of mesh of the other samples was unknown but they appeared to be finer than 60 mesh.

In an incomplete series of tests with a fifth *Tephrosia* sample (B.P.I. no. 200) containing no rotenone, the mortality with this undiluted sample against quarter-grown larvae was no greater than with the clay alone which was the diluent for the other samples.

SUMMARY.—Insecticidal dusts made from the powdered roots of *Derris elliptica*. *Lonchocarpus* sp. and *Tephrosia virginiana*, diluted with clay to contain uniform percentages of rotenone, were tested in the laboratory against larvae of the imported cabbage worm. For each material tested, 180 uniform quarter-grown

and an equal number of half-grown larvae of this species were used.

There was no significant difference in insecticidal efficiency between the averages of derris and the averages of cubé powders containing nearly equal percentages of rotenone and total extractives. One sample of cubé, however, was definitely inferior, contrary to what would have been expected from the chemical analyses.

Samples of *Tephrosia virginiana* diluted 1 to 3 with clay, with resulting rotenone contents as low as 0.042 per cent, were so toxic to quarter-grown larvae that no comparisons could be made.

The same dilutions of *Tephrosia* tested with the more resistant half-grown larvae did not differ significantly among themselves except for the sample ground coarser than 60 mesh, which was inferior to the best. The best sample of diluted *Tephrosia* was not inferior to a derris dust containing 0.5 per cent rotenone and was superior to one containing 0.1 per cent rotenone.—2-18-38.

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Biological Studies of the Tomato Worm on Tobacco in Florida, 1936 and 1937

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During 1936 and 1937 an intensive study on the biology of the tomato worm, *Protoparce sexta* (Johan.), has been conducted by the writers at Quincy, Fla. This particular species is commonly known throughout the greater part of the United States as an important pest of tomatoes. However, in the Quincy area, which comprises practically the entire southern district in which cigar-wrapper tobacco is produced, its attacks are confined almost entirely to tobacco. This might be considered partly due to the fact that other cultivated Solanaceae, such as tomatoes, peppers, eggplants and potatoes, are not grown extensively. Infestations on the existing acreage of such crops, however, are usually very light; and since observations indicate that little or no feeding occurs on wild members of the family, it appears that in this locality tobacco is the preferred host plant. Although cigar-wrapper tobacco is the main type produced, a certain amount of cigar filler is also grown. On both types *P. sexta* is a pest of considerable economic importance, but while probably the heaviest infestations occur on the latter, which is grown in the open, the greatest damage is undoubtedly inflicted on the wrapper crop because even the slightest injury to the leaves of this type detracts considerably from its value.

General observations on the biology of this important tobacco pest have been made at Quincy for a number of years, and, as previously stated, detailed studies have been in progress during 1936 and 1937. This paper is a preliminary report on the more important findings obtained through these observations and studies, and the statements and conclusions must be considered tentative rather than final. Only a general presentation of the more outstanding features of the work is included, since a complete and detailed paper is to be prepared later upon the completion of the present investigations.

LIFE HISTORY AND HABITS.—The eggs of the tomato worm are usually deposited along the outer edges of the lower surface of the tobacco leaf, although some may also be attached to the upper surface. Under insectary conditions the egg stage lasts from two to eight days, depending upon the temperature. The larval period, as determined from specimens reared in the insectary, lasts from 14 to 44 days; variations in temperature affect the length of this stage. It has been found that the normal number of instars is five, but in a relatively few instances six instars have

been noted. Pupal periods ranging in length from 18 to 386 days have been recorded, and in a limited number of cases it has been determined that this period may require almost two years. A summary of findings with regard to the lengths of the egg, larval and pupal periods is given in table 1.

Table 1.—Summary of the life cycle of *Protoparce sexta*, Quincy, Fla., 1936 and 1937.

Stage	Number of Specimens Observed	Length of Period in Days: Maximum	Minimum	Average
Egg	2,357	8	2	4.9
Larval	590	44	14	19.5
Pupal	320*	386	18	151.7
Total		*438*	*34*	*176.1*

* A considerable number of specimens have not completed the pupal period.

In general, the adults are active only at dusk, when feeding, mating and oviposition occur. During the daytime they conceal themselves under any convenient cover, usually in wooded areas adjacent to the tobacco fields. The larvae usually remain on the under surface of the leaves of the host plant, and it appears that feeding is almost continuous with the exception of a period before each molt when the head capsule is being shed. This period may sometimes last as long as 24 hours or more. Apparently the more tender portions of a leaf are the most favored, and this causes the larvae to move from leaf to leaf feeding on such portions until most of the leaves on the plant are partially consumed. Such a habit increases the damage to the wrapper crop, since more leaves are injured in this manner. It has been noted, however, that the unconsumed portions may be eaten when conditions render it necessary, and so far as is known a larva will not leave a tobacco plant so long as there is any leaf surface remaining.

SEASONAL HISTORY AND ABUNDANCE.—From the evidence at hand it appears probable that there are three complete generations of tomato worm a year in this area, and observations indicate that a partial fourth occurs. The first adults begin to emerge between the middle of April and the first of May. These individuals, which constitute what may be termed the spring brood, emerge from first-, second-, third- and probably fourth-generation pupae of the previous season, and some of them may originate from pupae which are almost two years old. The emergence of these adults is undoubtedly drawn out over a long period so that some of the moths are emerging simultaneously with first- and even second-generation individuals.

Egg laying begins shortly after emergence, and the first larvae probably complete their development by the latter part of May or the first of June. The average length of the pupal period at this time of the year is about two weeks; so first-generation adults begin to emerge from the middle to the last of June. The emergence period of this brood is probably much shorter than that of the spring brood, and the peak is reached within a few weeks. Some of the stragglers, however, undoubtedly emerge along with second-generation adults. The life cycle of the second generation is somewhat shorter than that of the first, owing to slightly higher temperatures, and the emergence of second-generation adults begins about the latter part of July. The emergence period of this brood is somewhat longer owing to a longer average pupal period, and the life cycle of this generation is also slightly longer; so the adults do not emerge until about the first of September. These moths deposit a number of eggs, but owing to adverse climatic conditions and lack of favored host plants very few of the resulting larvae complete their development. A few of them do enter the ground and pupate, but no adults emerge from such pupae until the following season.

The seasonal abundance fluctuates somewhat, but there is a more or less constant reduction in numbers from about the middle of July until the latter part of September. This is due to the marked seasonal reduction in the emergence of adults. For the past two seasons a study has been made of the emergence of adults from a series of pupation cages. From the records obtained it has been learned that there is a gradual decrease in emergence after about the first of July, until by the middle of August no further emergence occurs. All material entering the ground after this time overwinters in the pupal stage and does not emerge until the following year.

The greatest number of larvae ap-

parently is present in the field between the middle and latter part of July. Most of these larvae are the progeny of first-generation adults, which begin to emerge a few weeks prior to this time, and since the number of individuals comprising this generation is very large, and as the females deposit a greater average number of eggs the resulting number of larvae is consequently the largest of the season. This period of greatest abundance of larvae occurs during the height of the tobacco-growing season, and as a result much damage is done to the crop unless vigorous control measures are applied.

NATURAL ENEMIES.—A number of common birds prey upon the larvae, and some of the pupae are destroyed by moles and skunks. The eggs and larvae are attacked to some extent by a plant bug, *Cyrtopeltis varians* (Dist.), and by a large green spider, *Peucetia viridans* (Hentz). Larvae are also killed and eaten by a predacious wasp which has been identified as *Polistes fuscatus* var. *metricus* Say. Certain species of Diptera are apparently the only parasites of note in this area. These species attack the larval stage. Observations over a number of years indicated that *Sarcophaga lambens* Wied.—*S. sternodontis* Towns. as recorded by Aldrich (1927)—was the most important species involved, but the records obtained during more recent studies indicate that *Sturmia protoparcis* (Towns.) is now the most prevalent. It is rather interesting to note that little or no parasitization by species of *Apanteles* exists, which is quite contrary to the findings in other parts of the country. All of the foregoing natural enemies exert little direct control, since they are mostly active after the harvest of the commercial tobacco crop. They do play some part, however, in keeping the population of *Protoparce sexta* within certain limits.

It might be added that a bacterial disease of the larvae caused by *Bacillus sphingidis* White is somewhat prevalent in this area. Under field conditions, however, this disease is apparently of very little importance as a controlling agent.

CONTROL MEASURES SUGGESTED BY THESE STUDIES.—Owing to the fact that up to the present time no entirely satisfactory poisons have been discovered for controlling *Protoparce sexta* on tobacco, and since such methods of control usually depend upon a certain amount of feeding by the larvae with the resulting damage to the crop, control practices involving some of the other stages are of considerable value. While some of the practices mentioned below have been in use over a period of years and others are now in the process of investigation, the practicability of such methods has been indicated by the information obtained from the biological studies. The practice of destroying the tobacco stalks directly after the harvest, which is almost universally employed in this area, is based upon sound principles. Since observations indicate that tobacco is practically the only host plant, it is apparent that destruction of the food supply greatly reduces the number of overwintering pupae and thereby reduces the infestation during the following season. Fall plowing, which was recommended by Morgan (1910) as a valuable control measure in Tennessee, is also of practical value in the Quincy area. Experiments conducted at Quincy during a five-year period have shown that an average control of 50.19 per cent may be obtained by this method.

The control of *Protoparce sexta* by the use of moth traps and poison feeders has been described by Morgan & Lyon (1928) and Gilmore & Milam (1933). Both methods depend upon the attractiveness of certain chemicals to the adults, resulting in a pronounced feeding response on the part of the moths. The value of either of these methods has been indicated by observations made on the feeding and oviposition habits of the females under cage conditions. It was found that while there was an average preoviposition period of approximately two days, feeding always occurred on the evening of the day of emergence. Thus the possibility of catching or killing a considerable number of females before any oviposition occurs is apparent.

SUMMARY.—The attack of the tomato worm in the Quincy, Fla. district is confined principally to tobacco, although this species is considered to be primarily a pest of tomatoes.

In the insectary the egg stage lasted 4.9 days, the larval stage 19.5 and the pupal stage 151.7. In a limited number of instances the pupal period required almost two years. Three complete generations

and a partial fourth occur each year. The maximum seasonal abundance of larvae is reached during the middle and latter part of July, corresponding to the period of maximum rate of growth of the tobacco plants.

Although various kinds of natural enemies attack the tomato worm, including several species of parasites and predators and a bacterial disease, their combined effect exerts but little influence, since such enemies are most active after harvest.

In the absence of an entirely satisfactory insecticide for combating the tomato worm, the information obtained in these studies indicates the practicability of supplemental methods of control, including the destruction of the tobacco stalks directly after harvest, fall plowing of infested tobacco fields and the use of moth traps.—2-18-38.

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Observations on the Hornworms Attacking Tobacco in Tennessee and Kentucky

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The species of hornworms attacking tobacco, *Protoparce sexta* (Johan.) and *P. quinquemaculata* (Haw.), have been of much economic importance for many years in all tobacco growing districts of the United States, including 45 states within their range of distribution. The larvae often consume large portions of tobacco leaves in this territory, with resulting loss in weight of the harvested product as well as in the market value of the infested leaves. Where effective control measures have not been carried out, many entire fields of tobacco have been destroyed by hornworms.

The object of this paper is to present data from unpublished notes relating to hornworms made at the Clarksville, Tenn., laboratory of the Bureau of Entomology and Plant Quarantine. They cover a period of over 20 years and are based upon studies in Tennessee and Kentucky and to some extent in the bright-tobacco belt.

DESCRIPTION OF THE EGGS OF THE TWO SPECIES.—The egg of *Protoparce sexta*, the tomato worm, is light green in color, often becoming a lighter tinge of green within about 24 hours after being laid. It is oval and flattened above and below. The shell is tough, shiny, transparent and unmarked. Examination of 100 eggs showed them to average 1.48 millimeters (0.058 inch) in length and 1.34 millimeters (0.053 inch) in width.

The egg of *P. quinquemaculata*, the tobacco worm, is also light green in color, oval and somewhat flattened. The shell is tough, shiny and transparent. The eggs average 1.36 millimeters (0.054 inch) in length and 1.27 millimeters (0.050 inch) in width, being about one-tenth smaller than those of *P. sexta*. The eggs of both species are deposited singly.

DESCRIPTION OF THE LARVAE.—The full-grown larva of *P. sexta* is clothed with a fine white pubescence 0.5 millimeter (0.019 inch) long. The body is green, with seven oblique white lines, or bands, extending upward and backward, visible from a lateral view. Above each white band is a black line, originating anterad of and above each spiracle except the anterior and posterior ones. The true legs are marked with black at each articula-

* The author is grateful for the advice and direction of the late A. C. Morgan, who was for many years in charge of the Clarksville laboratory, and for cooperation in some of these studies to S. E. Crumb, K. B. McKinney and Joe Milam. The identifications of the species of insects listed in this paper were made by the Division of Insect Identification, Bureau of Entomology, U. S. Department of Agriculture.

tion. The prominent red horn, or anal spine, is curved backward and downward and provides an additional external character for separating this species from *P. quinquemaculata.*

The larva of *P. quinquemaculata* is not clothed with pubescence in the latter instars, as is *P. sexta.* The color of the body varies from vivid green to brown, with eight prominent greenish-yellow, V-shaped markings pointing anteriorly and embracing each spiracle except the anterior one. The lower line of the V-shaped marking is subparallel to the longitudinal plane of the larva, and the upper line extends obliquely upward and backward. Oval, pale yellowish-green spots cover much of the body. When melanism or other deviation from normal pigmentation occurs, brown, red and black predominate. The legs and the horn of the larva are black. The horn is more nearly erect than in *P. sexta.*

The larvae of the two species are difficult to separate in the first two instars. Later the oblique somatic markings, the presence or absence of the body pubescence, and the color and position of the prominent horn aid in differentiating the species.

The full-grown larvae of both species are from 12 to 14 millimeters (0.47–0.55 inch) wide and from 75 to 85 millimeters (3.0–3.5 inches) long, the average being 12.6 millimeters (0.50 inch) wide and 78.7 millimeters (3.1 inches) long. The average width of the head shield of both species in the last instar is 7 to 8 millimeters (0.28–0.31 inch).

DESCRIPTION OF THE PUPAE.—The pupae of both species of hornworms are dark reddish brown and blunt anteriorly. With the aid of a hand lens the outlines of the eyes, tongue, antennae, wing pads and genitalia of the adult can be recognized beneath the shiny sclerotized covering. The tongue case, or maxillary loop, varies in length and shape and is a convenient and satisfactory means of identifying the species. The maxillary loop of *P. sexta* is about 15 millimeters (0.59 inch) long, while that of *P. quinquemaculata* is from 22 to 28 millimeters (0.86–1.10 inch) long. The pupa of *P. quinquemaculata* has a longer and more curved tongue case than the pupa of *P. sexta.* In both species the antennal ridges of the males are nearly twice as wide as those of the females.

The pupae of both species range in length from 45 to 60 millimeters (1.77–2.36 inches) and in width from 13 to 14 millimeters (0.51–0.55 inch).

DESCRIPTION OF THE ADULTS.—The moths of both species of hornworms have large graceful bodies, which average about 50.8 millimeters (2 inches) long and 12.7 millimeters (0.5 inch) in diameter, and have a wing spread of about 114.3–127 millimeters (4.5–5.0 inches). The sexes are similar in color and markings in both species. The females are larger than the males as a rule and can be differentiated from them by the narrower antennae.

The moth of *P. sexta* has six orange spots located dorsolaterally on each side of the abdomen (on segments 3 to 8, inclusive). The moth of *P. quinquemaculata* has five similar, but paler, spots on each side of the abdomen (on segments 4 to 8, inclusive). The moth of *P. sexta* has an oblong white spot midway on each fore wing near the anterior margin. Near the base of the fore wing there is also a small white area situated partially upon the wing base and partially upon the thorax. The moth of *P. quinquemaculata* has neither the white spots on the fore wings nor the white area near the bases of the fore wings. The adult of *P. sexta* is slate brown and the general color tone is somewhat darker than the ash gray of *P. quinquemaculata.* Both species have an interrupted white margin on the distal edges of the fore wings and the posterior margins of the hind wings, but this white margin is much more prominent in *P. sexta.*

Both moths have extremely long tongues (maxillae) adapted to feeding in flowers that have long corollas. The average tongue length for 182 *P. sexta* males was found to be 76.7 millimeters (3.02 inches) while that of the females was 73.7 millimeters (2.89 inches). Both extremes were represented by the females, 92 millimeters (3.62 inches) and 58.5 millimeters (2.30 inches).

PROPORTION OF SPECIES AND SEXES.—Some early investigators believed that about 90 per cent of the hornworms infesting tobacco in Tennessee were tomato worms, *P. sexta.* According to the writer's observations, this species was usually more numerous in June and July, but in midsummer the two were about equal in

number, and in September the tobacco worms, *P. quinquemaculata*, predominated. These findings were based upon the examination of approximately 50,000 moths caught in trapping experiments over a period of several years. The catches were made by introducing isoamyl salicylate as an attractant in a trap developed by the writer (Gilmore & Milam 1935) for use in chemotropic experiments.

Often the number of trapped males slightly exceeded the number of females in both species. Records of moths newly emerged from hibernation and moths caught in the traps, however, showed the sexes to be practically equal in number.

One instance of apparent gynandromorphism was observed in an adult *P. sexta* that had one male and one female antenna.

MATING HABITS.—In captivity mating usually occurred during the second or third night after emergence, and it often lasted an hour or longer.

HABITS OF FLIGHT.—Before sunset, and earlier on cloudy days, hornworm moths often frequent fields where Jimson weed (*Datura stramonium*) and other favored flowers are growing, for the purpose of feeding on the blooms. During periods of heavy moth emergence hundreds of them may be seen visiting small patches of Jimson weed. They feed for about two hours after nightfall, and during this period large numbers of moths can be collected.

Some newly emerged males of both species were taken from hibernation cages in the spring and their wings marked with an alcoholic solution of fuchsin; they were then liberated at definite distances from large patches of Jimson weed. Out of a total of 300 moths liberated, only 3 were recovered, and these were found within 200 yards of the point of liberation.

In other experiments, specimens of both species were marked with tiny perforations made between the veins of the fore wing in such a way as not to impede their flight. These test moths had been taken from traps, and only the most active individuals with undamaged wings were used. Several marked moths were recovered at various distances from the point of liberation. Moths of both species were captured up to a distance of half a mile. The record flight from thousands of adults liberated was $1\frac{1}{4}$ miles, by a male of the tobacco worm which was taken two days after liberation.

Immediately after feeding, the gravid female moths search for a tobacco field in which to begin oviposition. Usually from one to five eggs are deposited on one plant. The moths may remain on the wing the entire night, especially if the weather is fair and there is moonlight. Many moths were captured in traps during each quarter period of the night, extending from 6 p.m. to 6 a.m. The largest number was caught prior to 9 p.m.; the fewest from midnight to 3 a.m. Renewed activity was apparent just before dawn.

EGGS IN THE LIFE HISTORY.—Many records of egg incubation for both species were made over a number of years. The average incubation period under summer conditions for 2,184 eggs was 3.97 days. Out of 2,332 eggs, 2,184, or 93.6 per cent, were fertile. The length of the egg stage of the tobacco worm is practically identical with that of the tomato worm.

LARVAE IN THE LIFE HISTORY.—The larvae of both species usually have five instars when they feed upon tobacco. In rare instances a sixth instar has been recorded.

In observations on 89 individuals of *P. sexta* the larval period ranged from 14.5 to 44 days, with an average of 21.5 days. The prepupal period, for 21 individuals, ranged from 2 to 6 days, with an average of 3.7 days. For 9 individuals of *P. quinquemaculata* the larval period ranged from 16.5 to 29.5 days, with an average of 23.0 days, and for 3 individuals the prepupal period was 3.0 to 5.0 days, with an average of 4.0 days.

The tomato worms were reared on dark-fired tobacco, and the quantity eaten by one larva was determined from the area of leaf devoured. The leaf consumption of 25 larvae under observation was, on an average, 0.10 square inch in the first instar, 0.36 in the second, 1.86 in the third, 16.32 in the fourth and 200.95 in the fifth instar. It will be seen that about 90 per cent of the total was eaten in the fifth instar.

The larvae of both species required as much as 20 to 30 hours to complete a molt, particularly in the last three instars. During such quiescent nonfeeding periods they remained on the underside of the tobacco leaf attached to the veins or

midrib. The head shields were observed to slip forward, and after several hours the skins ruptured proximodorsally and were then cast off over the anal segments. After about an hour the mandibles of the molted larvae had hardened and the larvae were prepared to feed again.

PUPAE IN THE LIFE HISTORY.—The mature larvae of both species burrowed into the soil obliquely to a depth of 4 to 7 inches and then formed an earthen cell about 1.5 by 3.0 inches in external measurements. The cell wall was about 0.25 inch thick. In one experiment a cage was constructed over the soil, which had been spaded to a depth of 6 inches and allowed to settle for several months. Several hundred full-grown larvae were admitted in June, and two weeks later each pupa was removed and the pupation depth determined. The average depth of pupation observed was 5.52 inches; the extreme depths were 10 inches and 1 inch. The records and observations did not indicate that larvae of either species go deeper in the soil for hibernation than in midsummer for pupation. The physical conditions of both the top soil and the subsoil and the percentage of moisture in the soil appear to be the factors which govern the depth of pupation.

The pupal periods for both species were practically identical in length. Records made in June, July and August over a number of years at Clarksville showed pupal periods to range from 17 to 25 days, with an average of 21 days for *P. sexta* and of 21.4 days for *P. quinquemaculata*.

The records of 13,498 larvae of *P. sexta* taken at random from data covering five years showed that 3,275 moths emerged, comprising a survival of 24.3 per cent. The average length of the hibernation period was 312.7 days. The average date of first emergence was July 5 and the latest emergence of spring moths was on August 2. Of the moths that emerged, 50.4 per cent were males and 49.6 per cent were females. A small percentage of the pupae hibernated for two years or longer. The five longest hibernation periods recorded during these studies averaged 790.4 days.

Under identical conditions and in the same locality, over a period of three years 4,468 larvae of *P. quinquemaculata* were placed in hibernation cages. Only 124 males and 88 females emerged, comprising a 4.8 per cent emergence. It is not known why the tobacco worm showed such a low survival compared with that of the tomato worm.

ADULTS IN THE LIFE HISTORY.—The emergence of hornworm moths from both the overwintering and the spring broods usually occurs over a period of approximately 90 days, commencing late in May and concluding some time in August.

Emergence from the pupal case occurs at night, and the moth climbs up the oblique tunnel that was prepared by the full-grown larva. The wings are soft when the moths reach the soil surface, and they usually require an hour or more to dry. After the wings have dried, the moths ordinarily find hiding places on tree trunks where, protected to a remarkable degree by their coloration, they remain during the daylight hours. At dusk and early in the evening the moths of both species may be seen feeding from flowers of Jimson weed (*Datura stramonium*), western catalpa (*Catalpa speciosa*), tobacco (*Nicotiana tabacum*), petunia (*Petunia axillaris*), wild potato vine (*Ipomoea pandurata*), trumpetcreeper (*Bignonia radicans*), common evening-primrose (*Oenothera biennis*), daylily (*Hemerocallis sp.*), mallow (*Hibiscus lasiocarpus*), four o'clock (*Mirabilis jalapa*), honeysuckle (*Lonicera sp.*) and hollyhock (*Althaea rosea*).

The preferred flowers appear to be Jimson weed and catalpa. After a short period of feeding, mating occurs, and in about four to six days after emergence the female moth begins ovipositing. Extensive field observations have shown that tobacco and tomato plants are preferred by both species for oviposition. Egg laying begins just before twilight, the female depositing from one to five eggs per plant at each visit. In captivity each adult of *Protoparce sexta* laid an average of about 500 eggs, and dissections of 100 virgin females of each species showed an average of approximately 2,000 ova per female. In tobacco fields the female moth flies leisurely along a row of tobacco and, while on the wing, deposits her eggs singly on the tip or margin of a leaf. The marginal underside of the distal one-third of the leaf appears to be preferred for egg deposition, as about 74 per cent of several thousand eggs collected by the writer and his associates were laid in

such locations. This habit of oviposition probably permits a higher percentage of eggs to hatch and indirectly contributes to a higher survival of the young larvae than would be the case if the eggs and newly hatched larvae were exposed to the direct rays of the sun on the upper side of the leaves. In fact, an extended series of field observations demonstrated that when an egg hatched on the upper side of the leaf at midday, with high temperatures prevailing, the frail larva was likely to succumb before feeding.

TYPES OF INJURY AND ECONOMIC IMPORTANCE.—The larvae from the hibernating generation of hornworms attack half-grown or smaller plants in most of the tobacco districts in June. At this time the plants may be killed outright, parts of the stalk itself being consumed either before or after all the leaves have been eaten. Later in the season, in July or early in August, when the second brood appears, the tobacco plants are well grown and the more valuable leaves are damaged severely. Feeding is begun at the point of egg deposition, usually on the underside of the leaf tip. The leaves chosen for egg deposition are generally located on the upper half of the plant. When the larvae reach the fourth instar, they may migrate during midday from the tip to the base of the leaf, thereby obtaining protection from the sun. Later in the day they sometimes return to the previous feeding point but more often crawl to an uninjured leaf to resume feeding. A single leaf of tobacco may contain more than sufficient food to rear a full-grown larva, but the nearly full-grown larva often travels about in feeding or in response to other stimuli until four or five leaves are damaged seriously. Practically all this severe damage occurs during the last five or six days of larval growth.

In fields of burley tobacco the plants are set closer together than in fields of many other varieties; consequently, the leaves are thin and tender and very palatable to the larvae. Under these conditions the hornworm larvae do not wander over the plant to any great extent. As a rule, one leaf of burley tobacco provides sufficient food to mature a single larva, although under some circumstances another leaf may also be fed upon. In general, there does not occur the degree of promiscuous feeding in burley that is found in other varieties of tobacco. In dark-fired tobacco the less valuable leaves at the top of the plant are injured most severely, whereas in burley the higher priced leaves lower down on the plant are more heavily attacked. In addition to the loss in weight of the cured tobacco due to hornworm feeding, the market value of the infested leaves is lowered on account of its unfavorable appearance.

SEASONAL OCCURRENCE OF THE STAGES.—Both species of hornworms hibernate as pupae. Emergence commences late in May and continues until about August 22, with the peak occurring late in July or the first week in August.

The second generation of each species develops principally from eggs deposited early in August. Larvae entering the soil subsequent to August 15 do not emerge as moths that year but hibernate in the pupal stage. The moth population that is present early in August represents the combined emergence from the first-generation adults and the peak of the emergence of the hibernating or overwintering brood. When the emergence peaks of these two broods coincide, there usually a very heavy egg deposition. This second brood of larvae causes the most damage to tobacco. Moths emerging from hibernation early in August produce only one generation, which overwinters as pupae. Occasionally larvae are plentiful on tobacco suckers early in October. These are principally the progeny of overwintering moths that emerged late in August and encountered temperatures that retarded their growth.

NATURAL CHECKS ON HORNWORM POPULATIONS.—Repeated experiments show that over 90 per cent of the pupae of hornworms can be killed by normal fall and winter plowing. Only about 25 per cent of the over-wintering pupae survive in the absence of such plowing. This explains why a low population of the species is present during the spring of the year. A further reduction in abundance of the species in the fall is affected by such parasites as the tachinids *Sturmia* spp. and *Winthemia quadripustulata* (F.), which attack mature larvae and kill them in either the prepupal or the pupal stage; the hymenopterous parasite *Apanteles congregatus* Say; and the egg predators *Chrysopa rufilabris* Burm., *Jalysus spinosus* Say and *Geocoris punctipes* Say.

The following parasites and predators have been collected from tobacco hornworms in Tennessee and Kentucky:

FROM *Protoparce sexta* (JOHAN.)

Egg parasites: *Telenomus nigriscapus* Ashm. *Trichogramma minutum* Riley., *T. sphingis* Ashm. (=*monilicornis*, Ashm.)

Egg predators: *Chrysopa rufilabris* Burm., *Geocoris punctipes* Say.

Larval parasites: *Sturmia incompta* V.d.W., *S. protoparcis* Towns., *Sarcophaga rapax* Walk., *Winthemia quadripustulata* (F.), *Zenillia amplexa* Coq., *Euplectrus plathypenae* Howard, *Apanteles congregatus* (Say).

Larval predators: *Chrysopa rufilabris* Burm., *Polistes* sp., *Calathus opaculus* LeC.

Parasites of pupae: *Sturmia protoparcis* Towns., *Winthemia quadripustulata* (F.), *Sarcophaga* spp.

Pupal predators: Lampyrid larvae, *Megaselia nigriceps* (Loew).

FROM *Protoparce quinquemaculata* (HAW.)

Egg predator: *Chrysopa rufilabris* Burm.

Parasites of larvae: *Winthemia quadripustulata* (F.), *Sarcophaga* spp., *Sturmia* sp., *S. incompta* V.d.W., *Apanteles congregatus* (Say), *Compsilura concinnata* Meigen.

Larval predator: *Chrysopa rufilabris* Burm.

Parasite of pupae: *Sturmia incompta* V.d.W.

The parasite *Apanteles congregatus* is an important enemy of hornworms, particularly late in the fall when the worms are feeding upon tobacco, tomato, pepper and certain wild hosts. It is of interest that the author has only once been successful in rearing *A. congregatus* on hornworm larvae which fed upon dark-fired tobacco, a tobacco that is high in nicotine content, although on many occasions he has observed a partial development of the parasitic larvae. All such larvae died, however, in the body of the host except in one instance. Such deaths were probably due, for the most part at least, to the presence of relatively large quantities of nicotine in the host larvae. Under similar conditions this parasite was reared to maturity when the hosts fed upon burley tobacco, Jimson weed plants, and tomato plants.

Predators on hornworm larvae appeared to play an unimportant part in the control of the two species of hornworms in tobacco fields. *Chrysopa rufilabris* and a species of wasp, *Polistes* sp., have been observed attacking hornworms during early instars.

Other natural checks on hornworm populations are drought, which may prevent or retard emergence of the adult, and a bacterial disease designated as "hornworm septicemia," which is caused by the organism *Bacillus sphingidis*. This disease affects both species of hornworms. Other occasional checks on the abundance of hornworms include a number of wild birds and domestic fowls, chickens and turkeys being particularly efficient. Skunks devour prepupae and pupae in large numbers, being able to locate them several inches below the soil surface. Moles also devour large numbers of the pupae of both the species of hornworms discussed here.

SUMMARY.—This paper gives the results of studies, made principally in Tennessee and Kentucky, upon two species of hornworms attacking tobacco, *Protoparce sexta* (Johan.) and *P. quinquemaculata* (Haw.). General descriptions of both species are given, together with the principal morphological features which serve to separate the two species.

In Tennessee *P. sexta* was more abundant than *P. quinquemaculata* during June and July, in midsummer the two species were approximately equal in numbers, and in September *P. quinquemaculata* predominated. The sexes of both species were present in practically equal numbers.

The moths feed on flowers of tobacco and other plants. The preferred flowers appear to be Jimson weed and catalpa. Marked moths were recovered at a maximum distance of $1\frac{1}{4}$ miles from the point of liberation. Ordinarily the moths fly freely throughout the entire nocturnal period, when weather conditions are favorable.

For both species of hornworms the average duration of each stage was approximately as follows: egg stage, 4 days; larval stage, 22 days; prepupal stage, 4 days; pupal stage, 21 days. A small percentage of pupae hibernated for two years or longer. The five longest hibernation periods averaged 790 days.

Although a single leaf of tobacco may contain sufficient food to complete the development of a larva, the nearly full-grown larvae often damage four or five leaves seriously. Practically all this severe damage occurs during the last five or six days of larval growth. In addition to the loss in weight of cured tobacco due to hornworm feeding, the market value of the damaged leaves is lowered on account of its unfavorable appearance.

The natural checks on hornworm populations include normal fall plowing, which kills over 90 per cent of the overwintering pupae; winter conditions, which ordinarily kill approximately 75 per cent of the overwintering pupae that survive other destructive agencies; parasites and predators affecting eggs, larvae and pupae; a bacterial disease; drought; and wild birds, domestic fowls, skunks and moles.—2-18-38.

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Notes on *Apanteles congregatus* (Say) as a Parasite of Tobacco Hornworms

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Apanteles congregatus (Say), described in 1836, is a larval parasite of certain Lepidoptera belonging to the family Sphingidae, including the tomato worm, *Protoparce sexta* (Johan.), the tobacco worm, *P. quinquemaculata* (Haw.), *P. sexta paphus* (Cram.), *Dolba hylaeus* (Drury), *Ceratomia catalpae* (Bdv.), *Sphinx chersis* (Hbn.), *Hyloicus kalmiae* (A. & S.), *Ampeloeca myron* (Cram.), *A. versicolor* (Harr.), *Atreides plebeja* (F.), *Pholus satellitia pandorus* (Hbn.), *P. achemon* (Drury) and *Sphecodina abbotti* (Swains.). Apparently *A. congregatus* is the only species of *Apanteles* recorded from these hosts. It occurs generally over at least the eastern half of the United States and in Canada, Brazil and Jamaica. Even though it has a wide distribution and is known to be of considerable importance as a parasite of *Protoparce sexta*, *P. quinquemaculata* and *Ceratomia catalpae*, comparatively few life-history observations have been published.

FIG. 1.—Cocoons of *Apanteles congregatus* (Say) attached to a fifth-instar larva of *Protoparce sexta* (Johan.).

DESCRIPTION OF IMMATURE STAGES.—The egg of *Apanteles congregatus* is elongated, pear shaped to oval and colorless. It has a very thin, unmarked covering. At its tip is a slender, short, capitate and slightly hooked appendage. Prior to oviposition the mature egg is 0.13 to 0.14 millimeter long and 0.03 to 0.04 millimeter broad. An egg dissected from a parasitized host measured 0.5 millimeter by 0.18 millimeter, an increase in size of about four times.

The newly hatched larva is white and measures about 1 by 3 millimeters. At its posterior end is a bladder-like evagination of the hind intestine, that may serve as an excretal receptacle, which increases in size as the larva grows. It is not present, however, after the larva emerges from the host to spin its cocoon.

The cocoon is formed separately and not imbedded in silk. It is white, opaque and semirigid. It is attached in a vertical position externally to the host. Immediately after pupation in the cocoon the pupa is light in color, with only parts of the head and thorax having brown or darker areas. When nearly mature it is black, except for amber-colored legs and for hyaline lateral areas on the first three abdominal segments. Fig. 1 is a photograph of cocoons attached to their host.

LIFE HISTORY AND HABITS. Observations showed that during oviposition by *Apanteles congregatus*, which was principally within the posterior segments of the host, its abdomen was bent downward and forward and the ovipositor inserted quickly. Attempted oviposition in the anterior portion of the host frequently resulted in the parasite being brushed off or killed before the act was accomplished.

Time requirements for the various developmental stages of *A. congregatus* were determined by rearing them from eggs deposited by unfertilized females upon various larval instars of *P. sexta* which had been reared from the egg stage under conditions believed to be such as to prevent accidental parasitization. Following oviposition each host was kept in a gauze-covered glass tumbler at room temperature (summer and fall) and fed upon various food plants until the parasites had matured.

Table 1.—Life-history records of *Apanteles congregatus* (Say) reared from eggs deposited by unfertilized females upon larvae of *Protoparce sexta* (Johan.) fed upon tomato, Jimson, and dark-fired tobacco. Clarksville, Tenn., September, 1915.

Specimen No.	Food Plant	Instar of Host	Time in Hours Larva Was Exposed to Unfertilized Female	Time in Days Before Appearance of Cocoons	Time in Days Between Appearance of Cocoons and Emergence of Parasites	Number of Adult Parasites	Time in Days Between Oviposition and Death of Host	Instar of Host at Death
1	Tomato	2	5	16	7	188	20	5
2	Tomato	4	5	7	7	98	9	5
3	Tobacco and Jimson	2	5½	14	6	154	22	—
4	Tomato	4	4	14	6	123	16	5
5	Tobacco and Jimson	2	5½	13	6	118	14	5
6	Tomato	4	5	7	7	124	8	5
7	Tomato	3	2½	8	8	35	9	4
8	Tomato	4	4	6*	—	60*	5	4
9	Jimson	5	6	—†	—	—	4†	5
10	Tomato	3	5	6	7	71	7	5
11	Tomato	4	5	5	7	116	6	5
12	Tomato	3	5	5	8	91	14	4
13	Tomato	5	5	9	—‡	218	—	4
14	Tobacco	2	3	18	—‡	7	—	5
Average		*3.4*	*4.7*	*9.8*	*6.9*	*111.9*§	*11.2*	

* Died as larvae during formation of cocoons.
† Larvae of *Apanteles congregatus* were present but an accurate count could not be made.
‡ Overwintered as larvae.
§ Average larvae produced by each host.

A number of eggs were deposited during each insertion of the ovipositor and the complete act required from 20 to 30 seconds. Observations over many years have indicated that *Protoparce sexta* appears to be the preferred host of *A. congregatus*, and that oviposition occurs most frequently in the second and third instars of the host larvae. The latter conclusion was reached from a comparison of the time required for development of the egg and larva of the parasite, table 1, with that found by the writer (1937, unpublished manuscript) for larval instars of *P. sexta*.

The data from this study are given in table 1 and show that from 1,343 adults completing development on 12 of the 14 hosts, an average of 9.8 days was required from oviposition to appearance of the parasite cocoon, and 6.9 days for the adult to emerge from the cocoon. Each host produced an average of about 112 parasite larvae, but observations showed that the same species of host produced larger numbers of the parasite under field conditions. A maximum of 377 mature parasite larvae

were dissected from a single larva of *P. sexta* collected in the field. Parasitized larvae of this species collected on tomatoes had produced an average of about 150 parasite cocoons per host.

Observations also showed that the average length of life of the parasitized host was somewhat longer under natural conditions. Table 1 shows that the hosts parasitized under experimental conditions lived an average of 11.2 days after oviposition by the parasite, while under field conditions it was observed that the host usually died in about 16 days. The parasitized larval host usually fed for a few days after oviposition by the parasite, molted one or more times and then remained quiet for a day or so prior to and during emergence of the parasite larvae, usually being very torpid after such emergence until its death occurred. The parasite larvae were seldom found numerously in the thoracic region of the host but lay inertly about the larger branches of its tracheal system toward the host's posterior end.

SEASONAL HISTORY.—Since *A. congregatus* usually becomes detached from the host and falls to the soil, where it may be partially protected by debris, it passes the winter as a larva within its cocoon.* The adult emerges the following spring, usually during April, well before larvae of *P. sexta* and *P. quinquemaculata* are present, thus making imperative its use of another host until they appear. With the exception of *P. sexta paphus* all of the hosts previously listed occur in the central sections of Tennessee and Kentucky. Practically uninterrupted breeding occurs on *P. sexta* and *P. quinquemaculata* from their first appearance until late in September; and usually during the latter part of summer, when the two hosts and the parasite are at their peak of abundance, 50 per cent or more of these hornworms are parasitized by *A. congregatus*. Parasitization of some of the other sphingid hosts is usually resumed after midsummer, when adults of *A. congregatus* are most abundant.

SUCCESSFUL PARASITIZATION AS INFLUENCED BY FOOD PLANT OF LARVAL HOST.—Although heavy parasitization of larvae of *P. sexta* and *P. quinquemaculata* has been commonly observed on many host plants in Kentucky, Tennessee, Virginia and elsewhere, external evidence of parasitization on these hosts has been noticeably absent on dark-fired tobacco in Tennessee and Kentucky. In this area specimens of heavily parasitized larvae of *P. sexta* have often been seen feeding on *Datura stramonium* L., *Physalis subglabrata* (Mackenzie & Bush), pepper, tomato and potato. In fact a very high percentage of parasitization by *Apanteles congregatus* occurs on *Protoparce sexta* feeding on tomatoes.

Experimentally, gross parasitization of *Protoparce sexta* was obtained when larvae, principally of the fourth instar, were fed upon tomato and Jimson, table 1, and upon burley tobacco. Repeated attempts to obtain the parasite cocoons on larvae reared solely upon dark-fired tobacco were generally unsuccessful. In only one instance, specimen no. 14, table 1, were cocoons obtained and then only 7, a very small number compared to an average ranging from 150 to 250 cocoons produced by host larvae feeding upon other plants. Two host larvae, table 1, that were fed about five days on dark-fired tobacco and then permanently transferred to Jimson at the time of parasitization produced 118 and 154 parasites, respectively.

It would seem rather evident, therefore that the larval host contained some toxic substance which, when present in certain concentrations, prevented the successful production of mature parasite larvae. Because of the number of such experiments which seemed definitely to limit the presence of this substance to dark-fired tobacco, and because this variety of tobacco has a rather high nicotine content, it is suggested that nicotine may be the toxic principle prohibiting or greatly limiting parasitization of hornworm larvae by *A. congregatus* on dark-fired tobacco. Many experiments have shown, however, that oviposition by *A. congregatus* and partial development of its larvae do occur on host larvae feeding on dark-fired tobacco, and that the death of the parasite results in that of the host also. Therefore the apparent scarcity of external evidence of larval parasitization by *A. congregatus* is not necessarily a measure of its value as a natural control of hornworm larvae on dark-fired tobacco.

* During the various spring and summer generations the time within the cocoon is about equally divided between the prepupal and pupal stages.

HYPERPARASITES.†—Four species of secondary parasites were found to attack *A. congregatus* in its cocoon. They were *Hypopteromalus tabacum* (Fitch), *Eupteromalus viridescens* (Walsh), *Horismenus floridanus* (Ashm.) and *Pleurotropis* sp. The first of these was reared by F. S. Chamberlin in Florida, and the others were reared at Clarksville, Tenn. On one occasion an adult of *E. viridescens* was observed as it oviposited within each of six cocoons of *A. congregatus*. The operation, completed in about two minutes, consisted of completely inserting the ovipositor into the cocoon after the hole had been drilled. After 17½ days the adults emerged, one for each host cocoon. In this particular instance of hyperparasitization by *Pleurotropis* sp. the host died as a larva within its cocoon and the secondary parasite pupated externally.

SUMMARY.—*Apanteles congregatus* (Say), a common parasite of certain sphingid larvae in the eastern half of the United States, Brazil, Canada and Jamaica, has as its preferred host the tomato worm, *Protoparce sexta* (Johan.). Oviposition usually occurs in the second and third instars of the larval host and the total life cycle under laboratory conditions during September was found to be about 17 days. An average of 9.8 days was required for the egg and larval stages, and 6.9 days for the prepupal and pupal stages. Under laboratory conditions an average of 112 parasite larvae was reared from each host and under field conditions the average was about 150.

A. congregatus passes the winter on the soil surface as a larva within its cocoon. It emerges usually during April and breeds on certain sphingid larvae until larvae of *P. sexta* and *P. quinquemaculata* (Haw.) appear. These two hosts and the parasite reach their peaks of abundance usually late in the summer, after which parasitization of some of the other sphingid hosts is resumed.

Under field conditions heavy parasitization by *A. congregatus* was observed on *P. sexta* and *P. quinquemaculata* that were feeding on tomato and other plants, but in only one instance when feeding on dark-fired tobacco. Experiments indicated that the host larva on this tobacco contained a toxic principle, probably nicotine, that prevented maturation of the parasite. This lack of external evidence of parasitism may not be a true measure of *A. congregatus* in controlling larvae of the tomato and tobacco worms on this type of tobacco because experiments showed that oviposition and partial development of the parasite occurred when the host larva fed on this kind of tobacco, and that mortality of the immature parasite resulted in that of the host.

Four species of hyperparasites were reared from *A. congregatus*, all secondary, one in Florida and three in Tennessee.—2-18-38.

† Determinations were made by A. B. Gahan, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Conditions Involved in the Severe Losses of Newly Set Tobacco in North Carolina, 1937

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Press reports on June 12, 1937, indicated that tobacco newly transplanted to the field in the vicinity of Mount Airy, N. C., was suffering from a "strange blight" and that loss in stands had reached alarming proportions. An immediate investigation resulted in confirmation of the losses sustained but in disagreement as to the causes involved. The greatest losses observed were in Surry, Yadkin and Stokes counties, followed by those in Forsyth and Guilford counties, all in the western part of North Carolina. Such loss was also common, but less severe, in Person, Granville and Vance counties in the northcentral part of the state. In the more severely affected areas from three to five practically complete replantings were made. In most instances further replanting was prevented by lack of plants and lateness of season. Even with the unusually large amount of replanting, the final stands were in general below the average. Many fields contained such poor

FIG. 1.—A field of newly transplanted tobacco in Yadkin County, N. C., showing severe loss in stands from injury caused principally by the tobacco flea beetle, *Epitrix parvula* (F.); June 13, 1937.

stands, fig. 1, that the plants were plowed up and the fields were seeded to other crops.

Tobacco growers interviewed during the investigation stated that, while soil and weather conditions in general had been very suitable for successful establishment and growth of the transplants, the mortality of the newly set plants was greater during 1937 than had been observed heretofore. These growers stated that the affected plants lived for about one week after transplanting and that large numbers of the tobacco flea beetle, *Epitrix parvula* (F.), were feeding on the plant tops, fig. 2. At the end of about ten days it became evident that the plants were slow in becoming established. Within the next few days the most severely affected plants wilted and died, and those less severely affected remained alive but made practically no growth for several weeks. It was apparent that the characteristic wilting of the plants may have resulted either from some sort of toxic substance coming in contact with the plant or from excessive feeding of the beetle. Many growers observed that the replants developed typical symptoms more quickly than those first set and that the mortality of such plants was higher. In many of the severely injured plants a soft rot of the stem developed just beneath the level of the soil surface, while small whitish larvae, resembling wireworms, were found in some of the stems.

FIELD INJURY OBSERVED.—Examinations showed that the leaves on a majority of the affected plants had been riddled severely with feeding punctures of the tobacco flea beetle. Portions of many of the roots were injured or dead, and some stems contained from one to many tortuous, small burrows, which appeared from the outside as slender, brownish streaks. Frequently the tunnels showed complete destruction of the cortical layer. Although these tunnels were usually located in the cambium layer, in some instances they extended well into and through the stem. The tunnels began at almost any point on the subterranean portion of the stem and usually developed in a spiral manner. Frequently a tunnel extended above the soil surface into the midrib of one of the lower leaves. A small whitish beetle larva was occasionally found in the upper end of a tunnel, but in many instances the tunnel was empty, the larva apparently having left the stem for pupation in the soil. The larvae were identified as those of the tobacco flea beetle.* Fig. 3 is a drawing from a photograph showing a section of a typical stem tunnel, with the larva of *Epitrix parvula* that made it.

* This identification was verified after similar larvae had been taken from stems of newly set tobacco at Oxford, N. C., on which has been caged adults of *Epitrix parvula* only.

Many of the stems of injured plants that were alive had developed a soft rot in the region where larval tunnels were most numerous. Stems were found in various stages of decay as a result of invasions by soft-rot-producing organisms. In all cases it appeared that the soft rot was a secondary condition and that invasion by the organisms was initiated at the tunnel made by the flea beetle.

Stem injury by wireworms (Elateridae), in general, was rarely found, but injury by larvae of Crambidae was occasionally found in a number of fields; however, losses resulting from both kinds were minor in importance.

FIG. 2.—Two newly set tobacco plants, showing severe feeding injury by the tobacco flea beetle, typical of many of those in the area suffering greatest loss in stands.

Some growers were of the opinion that downy mildew (blue mold), *Peronospora nicotianae* Spegazzini, may have caused the serious damage, but this was not substantiated by extensive studies, since in many instances, according to Wolf *et al.* (1934), it is a disease almost strictly of juvenile plants in the seed bed. This disease did not appear in serious form in

FIG. 3.—A drawing from a photograph showing a section of a typical tunnel in a stem of newly set tobacco, together with the larva of *Epitrix parvula* that made it. (×14.)

plant beds of the area most heavily injured.

Some growers were of the opinion that the damage was caused by fertilizers, but this was not found to be so general as the widespread beetle damage, which was severe irrespective of the many brands and the great variations in the quantity of fertilizers used in that area. Fertilizer injury was generally seen where heavy applications were not well mixed with the soil and where plants were set in contact with it. In the later transplantings, when long-stemmed, woody plants were used, this type of fertilizer injury was most pronounced. Hot and dry weather also contributed to the losses in late transplantings.

PREVIOUS OBSERVATIONS OF INJURY BY TOBACCO FLEA BEETLE.—Many records show that severe feeding injury by adults of the tobacco flea beetle has occurred on leaves of tobacco in all stages of development, and it has been known that larvae of this beetle feed upon and, in some instances, apparently cause considerable injury to roots of tobacco. No records were found, however, in which the habit of tunneling the subterranean portions of stems of tobacco had been so commonly observed as that on the newly set tobacco in 1937.

Chittenden (1898) stated that the larval habits of the genus *Epitrix* were unknown prior to about 1897 and that F. C. Stewart and F. A. Sirrine found the larvae of the potato flea beetle, *E. cucumeris* Harr., "boring into the tubers, roots and rootstalks of potato." Chittenden and F. C. Pratt found larvae and pupae of *E. parvula* in the soil immediately around Jimson weed, *Datura stramonium* L., and the common black nightshade, *Solanum nigrum* L.

Morgan (1910) stated that, while the principal injury to tobacco by *E. parvula* was due to the feeding of the adults upon the foliage: "the larvae occasionally do considerable damage to the young plants by feeding upon the roots and stems."

Metcalf & Underhill (1919) conducted life-history studies of *E. parvula* and stated, with reference to the larvae: "In special cases it has been found that they not only feed upon, but often tunnel the stalks of tobacco and ground cherry plants for a distance of several inches. This is especially noticeable if the plants are accidentally partly buried." In the field, however, they normally found the larvae only in the soil among the fine rootlets of tobacco.

Chamberlin *et al.* (1924) also conducted life-history studies upon this beetle and found that the larvae frequently bored into and tunneled the roots of tobacco during the first instar, but older larvae fed from the outside, usually girdling or gnawing completely through the roots and completely severing them from the plant.

VERIFICATION OF FIELD OBSERVATIONS. A series of experiments was conducted at intervals throughout the summer of 1937 at Oxford, N. C., to determine if the root and stem injuries observed on tobacco plants in the severely affected area were caused by immature stages of the tobacco flea beetle. In these experiments tobacco plants of ordinary transplanting size were used and no fertilizer was applied under any of the newly set plants. Except for one series in which the plants were potted and kept in the shade, all plants were set in an open field. Varying numbers of adults of *E. parvula* were confined in cages on some of the plants; other plants were caged and kept free of beetles; and still other plants were not caged, being subjected to the normal field infestation of beetles. After the expiration of approximately 15 days all of the plants in each series were examined and their condition recorded.

Records from 129 plants on which beetles had been confined showed that only 91 plants were alive at the time of examination. Of this number, 69 plants had from 1 to 15 larval tunnels in each stem. Examination of the stems of dead plants in which decay had not progressed far enough to obscure insect injury showed that many of them had been tunneled by larvae. The degree of feeding injury by the adults on most of the plant tops was moderate to severe. Practically all of the infested, caged plants had root injury very similar to that on plants in fields of the severely affected area. Soft rot typical of that observed in the field was found on several of the more severely tunneled stems. At the time of examination the plants that had been caged and kept free of beetles were larger and more vigorous and had larger and more healthy root systems than those on which beetles

had been confined or those which had been exposed to natural infestation. Therefore, under experimental conditions, it was possible to obtain throughout the summer all of the principal symptoms observed on newly set plants in fields of the severely affected area. The evidence indicates that injury by adults on the plant tops and by larvae in the stems and on the roots exerts an influence upon the mortality and growth rate of newly set tobacco, although no indication was obtained as to the relative importance of the two kinds of injury.

SUMMARY.—There were severe losses in stands of newly transplanted tobacco late in May and in June, 1937, in the western and northcentral sections of North Carolina. So severe were the losses, particularly in the western part of the state, that a considerable acreage was plowed up and seeded to other crops. Even after as many as three to five practically complete replantings over much of the severely affected area, final stands were below average. Although the mortality of plants and the subsequent slow rate of plant growth were undoubtedly influenced by a combination of factors, such as feeding injury by wireworms (Elateridae) and larvae of Crambidae, injury resulting from the improper placement of fertilizer in the ridges on which transplanting was done, the size and condition of the plants used in the late transplantings, and inclement weather during the late transplantings, on a major portion of the affected plants examined the most important factor involved appeared to be the injury caused by the feeding of adults of the tobacco flea beetle on the plant tops and by larvae of this beetle on the roots and in the stems. All of the characteristic symptoms of the described injury were obtained at Oxford, N. C., throughout the summer of 1937, on newly set tobacco on which adults of the tobacco flea beetle had been confined. Apparently such severe injury by this beetle on newly set tobacco had not previously been observed over such a wide area, particularly that injury caused by the larvae of the beetle in tunneling the subterranean portion of the stems.—2-18-38.

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Some Applications of Mathematics to an Insect Life-History Study*

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This paper gives some of the results obtained in studying the life history of the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis). The turnip aphid is widely distributed over the United States and southern Canada and is one of the more important insect pests of cruciferous crops. It is a small, soft bodied, green plant louse that attacks turnips, kale, cabbage, mustard and related crops, and feeds by sucking the plant juices. Where the aphids are very abundant, young plants are killed outright and older plants made worthless for human food.

EXPERIMENTAL PROCEDURE.—The studies were conducted in an outdoor insectary and the results included in this report were obtained by confining individual females on young plants in separate containers and making observations daily.

* This study was carried on at the Baton Rouge, La., Laboratory of the Bureau of Entomology and Plant Quarantine, with the cooperation of the Louisiana Agricultural Experiment Station.

Table 1.—Showing the average growth or developmental period, the average reproductive period, and the average length of life of the female turnip aphid (*Rhopalosiphum pseudobrassicae*), and the average temperatures from July, 1933, through June, 1934, Baton Rouge, La. The index number for each of these values (using the average of each array as a base) is also shown.

Month Females Were Born	Number of Females	Growth Period		Reproductive Period		Length of Life		Temperature in Degrees F.	
		Average, Days	Index No., Per Cent	Average, Days	Index No., Per Cent	Average, Days	Index No., Per Cent	Average	Index No., Per Cent
July	29	5.72	60	9.72	61	16.38	52	76.95	115
Aug.	25	5.88	62	12.56	79	18.72	59	77.34	116
Sept	30	5.80	61	14.53	91	22.56	72	74.24	111
Oct	25	7.60	80	21.04	132	38.00	121	61.97	93
Nov	10	11.80	123	18.10	113	43.91	139	58.74	88
Dec.	15	11.80	123	23.26	146	43.00	136	55.34	83
Jan.	8	17.25	181	17.75	111	43.87	139	53.42	80
Feb.	6	16.33	171	19.75	124	45.16	143	57.15	86
March	6	12.33	129	18.00	113	42.00	133	63.05	94
April	9	8.55	90	12.00	75	23.33	74	69.31	104
May	12	6.41	67	14.50	91	24.41	77	74.48	112
June	10	5.20	54	10.60	66	16.80	53	79.52	119
Yearly average		*9.55*		*15.98*		*31.51*		*66.79*	

The index numbers listed in this table were used to plot the graphs used for illustrations in figure 1.

In this study, as with all similar studies, it was necessary to know the effect of temperature on the species. Accordingly, the temperatures for each two hours of every female's life period were secured from a hygrothermograph that was kept in a standard Weather Bureau instrument shelter approximately 100 yards from the insectary where the life history studies were made. All females that were born in any single month were grouped together and the average temperatures for the life periods of all of these averaged for the monthly temperature used in this paper.

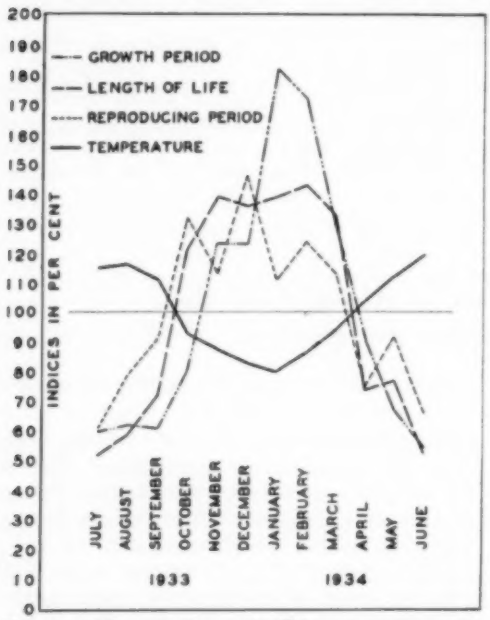

FIG. 1.—A graph illustrating the average growth period, the average reproducing period and the average length of life of the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis); and the average temperature from July, 1933, through June, 1934, Baton Rouge, La.

MATHEMATICAL APPLICATIONS.—In an effort to draw reliable conclusions from the data certain applications of mathematics have been made.† The mathematical principles used in the presentation of the results are elementary, but the study, as here treated, specifically illustrates the effective use of index numbers in reducing data to purely relative values for comparative purposes and serves to illustrate how the index numbers, when plotted, indicates the direction and something of the value of the coefficient of correlation.

To avoid the necessity of plotting the temperatures to one scale and the days to another, the variables were changed to index numbers and expressed as per cent.

† This article is an outgrowth of a study of the Mathematical Part of Statistics, a subject taught by Dr. Irby C. Nichols, Professor of Mathematics, Louisiana State University, to whom the writer wishes to express his appreciation for suggestions and criticisms in connection with the preparation of this manuscript.

Table 2.—Showing the departure of the observed values from the estimated values.

Month	Observed Temperature, Degrees F.	Observed Length of Life, Days	Values Estimated From $Y=112.53257-1.213025\,X$	Departure of Observed From Estimated Days
July	76.95	16.38	19.19	−2.81
Aug.	77.34	18.72	18.72	0.00
Sept.	74.24	22.56	22.48	+0.08
Oct.	61.97	38.00	37.36	+0.64
Nov.	58.74	43.91	41.28	+2.63
Dec.	55.34	43.00	45.40	−2.40
Jan.	53.42	43.87	47.73	−3.86
Feb.	57.15	45.16	43.21	+1.95
March	63.05	42.00	36.05	+5.95
April	69.31	23.33	28.46	−5.13
May	74.48	24.41	22.19	+2.22
June	79.52	16.80	16.07	+0.73

The values used, and their respective index numbers obtained by expressing the average for a given period as a percentage of the yearly average, are listed in table 1, and a comparison of the results illustrated in fig. 1.

RESULTS OBTAINED.—By reference to fig. 1 it may be seen that the rate of growth, the reproductive period and the length of life of the turnip aphids born during each month of the year were markedly influenced by temperature.

To determine the relationship between the average temperature and the different phases of the life history studied, the coefficient of correlation between the average temperature and the average growth period of insects born in each month, the average temperature and the average reproductive period, and the average temperature and average length of life were calculated.

The correlation coefficients were calculated by a form of the product-moment formula, as follows:

$$r=\frac{\text{Sum } XY-(\text{Sum } X)\text{ mean } Y}{\sqrt{\text{Sum } X^2-(\text{Sum } X)\text{ mean } X}\quad\sqrt{\text{Sum } Y^2-(\text{Sum } Y)\text{ mean } Y}}$$

The correlation coefficients were as follows: Growth and temperature, −0.8957; reproductive period and temperature, −0.8670; and length of life and temperature, −0.9654. All correlation coefficients were negative, showing that the higher the temperature the shorter the period. Wallace & Snedecor (1931) give 0.576 as being significant and 0.708 as being highly significant. These significant figures are for probabilities of 0.05 and 0.01, respectively.

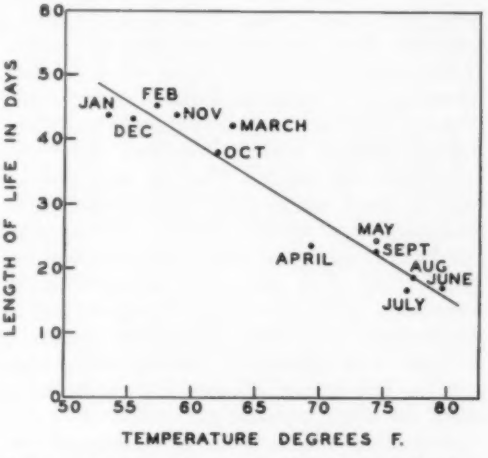

FIG. 2.—Scatter diagram showing the relation between temperature and the length of life, in days, of the turnip aphids born in each month of the year. (Derived from the equation $Y=112.53257-1.213025X$.)

A scatter diagram associating the average temperature with the average length of life, for the 12-month cycle, and the regression line are shown in fig. 2.

In the last column of table 2 are listed the errors of estimate obtained from the regression equation $Y=112.53257-1.213025X$, where X represents the temperature in degrees F., and Y the length of life.—2-18-38.

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Control of the Obscure Scale on Pecan With Low Concentrations of Lubricating Oil Emulsions

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Experiments were conducted near Shreveport, La., during the period 1934 to 1937, inclusive, to determine the effectiveness of low concentrations of lubricating oil emulsions in the control of the obscure scale, *Chrysomphalus obscurus* (Comst.), on pecan. The results of investigations on this insect conducted by Howard Baker, in charge of the Shreveport laboratory from 1929 to 1932, have already been published (Baker 1933). This work and that carried on by other investigators indicated that pecan trees low in vigor are very susceptible to injury by oil sprays, and it therefore appeared desirable to reduce the oil content of sprays used on pecan trees to the minimum required for the control of the scale. In 1933 Baker observed (unpublished report) that a 4 per cent lubricating oil emulsion exerted a control in addition to that shown by direct kill of the scale, by reason of a failure of female scales surviving the spray application to develop and produce young normally. The investigation which forms the basis of the present paper therefore included further observations on this point.

MATERIALS AND METHODS.—The characteristics of oils used in these experiments are given in table 1. The lubricating oils were emulsified by the cold-stirred method, with rosin-potash-fish-oil soap, except for the tank-mixed sprays, in which powdered blood albumin was used. One commercially prepared summer emulsion of highly refined oil was used in 1937.

All sprays were applied with power machines developing from 300 to 400 pounds of pressure with spray nozzles open. A disc-nozzle type of spray gun was used, both with and without the shade-tree tip attachment. For pecan trees 25 to 35 years of age and about 50 feet in height, the quantity of spray applied was approximately 30 gallons per tree in 1934; this was increased to approximately 50 gallons per tree in 1935, 1936 and 1937.

Spray plots containing from 2 to 12 pecan trees each were arranged so that unsprayed trees alternated with sprayed trees. Three to six months after the spray applications, sample scale-infested branches were taken from all sides and at different heights of these trees; 2- and 3-inch sections of these branches were examined under a binocular microscope for female scales. In 1934 and 1935 counts were made of dead scales and of those that matured and deposited eggs. In 1936 and 1937 the living female scales that failed to deposit eggs after reaching the adult stage were counted also. Additional counts were made of apparently mature female scales that survived the spray applications to determine the percentage that were to produce young.

Table 1.—Characteristics of oils used in spraying experiments for control of the obscure scale, Shreveport, La., 1934–1937.*

Oil No.	Viscosity, Saybolt, at 100°F., Seconds	Unsulfonatable, Per Cent	Volatility, Four Hours at 100°C., Per Cent
1	60	88	1.6
2	150	82	0.3
3	100	100	0.4
4†	60	96	1.5

* Analyses made by the Division of Insecticide Investigations.
† Proprietary summer-oil emulsion, 80 per cent oil.

RESULTS.—The results of these experiments are summarized in table 2. Sprays at concentrations of 3 and 4 per cent failed to give adequate control of the scale in 1934. The kill was uneven, appar-

* The writer expresses his appreciation of the interest and helpful suggestions of C. B. Nickels, under whose general direction this work was performed. He expresses his thanks to B. G. Sitton and H. E. Parson, of the Bureau of Plant Industry, for cooperation and use of equipment.

ently because insufficient quantities of the spray material were used to wet thoroughly all parts of infested branches. In 1935, 1936 and 1937 adequate control of the scale was effected with 3 and 4 per cent oil emulsions by increasing the sprays effected more than 80 per cent control of the scale by direct kill combined with the failure of surviving females to deposit eggs. Three per cent emulsions caused a higher direct kill than 2 per cent emulsions, but the final differences were

Table 2.—Effectiveness of oil emulsion sprays for control of the obscure scale on pecan, Shreveport, La., 1934–1937.

Treatment	Oil Concentration, Per Cent	Date of Application	Female Scales Examined				Per Cent Control
			Total Number	Per Cent Dead	Per Cent Not to Produce Young	Per Cent To Produce Young	
		1934					
Oil 1	3.00	March 20	1,968	71.4	—	28.6	66.9
	4.00	March 20	2,412	77.1	—	22.9	73.5
Unsprayed check	—	—	1,798	13.6	—	86.4	—
		1935					
Oil 1	3.00	March 15	5,289	93.4	—	6.6	92.8
Oil 2	3.50	March 15	6,714	98.1	—	1.9	97.9
	4.00	March 19	6,123	96.2	—	3.8	95.8
Unsprayed check	—	—	3,611	8.3	—	91.7	—
		1936					
Oil 1	2.00	Jan. 25	3,420	36.7	47.7	15.6	81.3
	3.00	Jan. 24 and March 13	7,780	73.9	16.5	9.6	88.5
	4.00	Jan. 25 and March 10	5,220	88.3	8.7	3.0	96.4
Oil 3	3.00	March 13	2,250	83.1	11.8	5.1	93.9
	4.00	March 10	3,270	91.0	5.1	3.9	95.3
Oil 2	2.00	March 13	4,370	60.3	31.6	8.1	90.3
	3.00	March 13	1,960	78.3	15.3	6.4	92.3
Unsprayed check	—	—	3,750	7.2	9.2	83.6	—
		1937					
Oil 4	2.00	Feb. 17 and March 12	3,320	52.4	40.8	6.8	88.9
	4.00	Feb. 17 and March 11	3,490	81.4	16.1	2.5	95.9
Oil 2	2.00	Feb. 17 and March 12	4,780	49.9	46.3	3.8	93.7
Oil 2, tank mixture	2.25	March 12	1,080	62.9	35.8	1.3	97.9
Oil 2	3.00	March 12	1,430	73.3	25.4	1.3	97.9
Oil 2, tank mixture	3.00	March 12	1,450	53.5	44.9	1.6	97.4
Oil 2	4.00	Feb. 16 and March 11	3,540	90.3	7.8	1.9	96.8
Unsprayed check	—	—	4,060	10.1	29.2	60.7	—

quantity of spray material applied per tree.

Further data on the effect of oil emulsion sprays on female scales surviving the spray applications and reaching maturity, in experiments conducted in 1936 and 1937, are shown in table 3. Most of the female scales which survived the spray applications failed to deposit eggs or to produce young after reaching maturity. Examinations of adult female scales affected by the oil sprays indicated that most of them did not develop eggs. This was apparent throughout the period in which normal adult females were developing and depositing eggs. Two per cent oil emulsion much less owing to the delayed effect of the oil on surviving female scales. Four per cent oil emulsion sprays effected good control by direct kill of the scale, but in some instances severe injury to pecan trees resulted.

In November, 1937, a study was made of the scale population on pecan trees sprayed in 1936 and in 1937 as compared with the scale population on unsprayed trees. This study indicated that the obscure scale can be held in check on pecan trees by spraying every other year with oil emulsions if the control effected is above 90 per cent.

OIL INJURY TO PECAN TREES.—The injury to pecan trees caused by oil emulsion sprays applied in the dormant period varied from a delay in development of foliage to a killing back of the lower branches. The delay in development of foliage was very noticeable on trees sprayed with 2, 3 and 4 per cent oil emulsions when the quantity of actual oil applied per tree was from 1 to 2 gallons. Branches may or may not be killed depending on tree vigor and time of spray applications, but killing occurred most frequently on trees sprayed with 3 and 4 per cent oil emulsions when the quantity of oil applied per tree was from $1\frac{1}{2}$ to 2 gallons. Oil injury to pecan apparently was not affected by the degree of refinement, viscosity or method of emulsifying the oil.

CONCLUSIONS.—Most of the female scales surviving thorough applications of 2, 3 and 4 per cent oil emulsion sprays failed to develop eggs and produce young. The use of a 2 per cent oil emulsion spray is suggested for holding in check infestations of the obscure scale on pecan trees low in vigor or growing in poor upland soils. Three per cent oil emulsion sprays effect a much higher direct kill of scale than 2 per cent concentrations, and their general use in control of the obscure scale on pecan trees growing in alluvial soil seems justified. A 4 per cent oil emulsion was the lowest concentration that consistently effected a high degree of control by direct kill of the scale, but severe injury to the pecan tree has resulted from the use of this concentration.—6-27-38.

Table 3.—Effect of oil emulsion sprays on obscure scale females that survived spray applications, Shreveport, La., 1936–1937.

TREATMENT	OIL CONCENTRATION, PER CENT	DATE APPLIED	NUMBER OF SCALES EXAMINED	PER CENT OF SCALES TO PRODUCE YOUNG
		1936		
Oils 1, 2, 3*	2.00, 3.00, 4.00	Jan. 24, 25 and March 10, 13	1,368	42.0
Unsprayed check*	—	—	500	98.2
Oil 1	2.00	Jan. 25	3,215	25.2
	3.00	Jan. 24 and March 13	3,642	35.5
	4.00	Jan. 25 and March 10	1,392	22.4
Oil 3	3.00	March 13	801	26.1
	4.00	March 10	834	35.0
Oil 2	2.00	March 13	2,763	19.5
	3.00	March 13	846	21.6
Unsprayed check	—	—	4,830	90.3
		1937		
Oil 2*	2.00	Feb. 17 and March 12	1,880	1.3
	3.00	March 12	690	1.9
Unsprayed check*	—	—	520	86.0
Oil 4	2.00	Feb. 17 and March 12	4,030	14.3
	4.00	Feb. 17 and March 12	1,860	12.4
Oil 2	2.00	Feb. 17 and March 12	5,946	9.4
Oil 2, tank mixture	2.25	March 12	1,101	5.1
Oil 2	3.00	March 12	1,482	6.1
Oil 2, tank mixture	3.00	March 12	1,574	3.1
Oil 2	4.00	Feb. 16 and March 11	1,354	22.2
Unsprayed check	—	—	6,951	71.3

* Counts made approximately one month after beginning of egg deposition. All other counts made near the end of the oviposition period.

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Recent Experiments With Ethylene Dichloride Emulsion for Peach Borer Control

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The purpose of this paper is to place on record the results of experiments carried on with ethylene dichloride emulsion for the control of the peach borer, *Conopia exitiosa* (Say), during 1936 and 1937. Results of earlier experiments were reported at the Cotton States Branch meeting by the writer and J. R. Thomson, Jr. (1936), two years ago. The results obtained under conditions existing in central Georgia have since been confirmed by further experiments carried on in the same locality as well as by cooperative tests carried on in southern Illinois and western New York.*

The characteristics of ethylene dichloride have been given in detail by Cotton & Roark (1927) and by Back & Cotton (1935) and will not be described here. The emulsions were prepared, as formerly, by stirring 9 parts by volume of ethylene dichloride into 1 part by volume of a potash fish-oil soap containing approximately 30 per cent of soap. This mixture was then diluted with water to the required strength.

The results of comparative tests conducted in September and October 1937 in New York, Illinois and Georgia are given in detail in table 1. The materials were applied during the following periods: In western New York, September 16–21; in southern Illinois, September 25–29; at Fort Valley, Ga., October 20–23.

Table 2 reports the results of experiments with ethylene dichloride emulsion which were carried on in Georgia during December, 1936, and January and February, 1937, and in New York in November, 1937, when the soil temperatures were considerably lower than at the times when paradichlorobenzene crystals are usually applied for the control of the peach borer.

The applications of the ethylene dichloride emulsions were made in two ways. The first method consisted of spraying the soil immediately surrounding the tree, allowing the lower part of the trunk of each tree to receive some of the spray. By the second method the liquid was poured around the base of each tree. Because the results as to borer control were practically the same by both methods, the figures have been combined in the tables. The paradichlorobenzene crystals were applied by standard methods.

NOTES ON INJURY.—In all of these experiments the ethylene dichloride emulsion caused injury to only two trees—one two-year-old tree in Georgia treated with $\frac{1}{4}$ pint of 20 per cent emulsion in October, 1937, and one three-year-old tree in New York, treated in November, 1937, with $\frac{1}{2}$ pint of 15 per cent emulsion. In each case of injury, which was limited in extent, the material was applied by pouring, and the damage may have resulted from the poured dose running down holes close to the tree.

Paradichlorobenzene caused injury to a number of the younger trees used in the tests. In New York and Illinois it was found advisable to remove the material from around the younger trees at the end of two weeks time, in order to prevent further injury. In Georgia some injury occurred to trees one and two years old.

DISCUSSION.—Throughout the experiments the higher dosages of the ethylene dichloride emulsion gave a high degree of control of the peach borer. This material maintained its effectiveness late in the fall in New York and during the winter in Georgia, when soil temperatures were too low for the effective use of paradichlorobenzene. Good results were obtained both by spraying and by pouring the material. The spraying method appears less likely to result in injury to the trees, probably because it gives a more even distribution of the emulsion. In the cold weather tests of paradichlorobenzene some of the records were taken four to seven days after treatment, and the rest were taken after intervals of one month. In neither case was there indication of much borer mortality.

In addition to the advantages of less danger of injury, and of greater effective-

* In Illinois the experiments were conducted in cooperation with W. P. Flint and S. C. Chandler of the Illinois Natural History Survey and the Illinois Agricultural Experiment Station; in New York the work was carried on cooperatively with P. J. Parrott, D. M. Daniel and James E. Dewey of the New York State Agricultural Experiment Station. J. R. Thomson, Jr., has assisted throughout in the work in Georgia.

ness when soil temperatures are low, than is the case with paradichlorobenzene, the ethylene dichloride treatment is slightly less expensive, the cost of the materials being about 0.9 cent per mature tree as compared with 1.1 cents per tree for paradichlorobenzene.

From the experience gained from tests with ethylene dichloride, the following dosages are suggested as sufficient to give effective control with a minimum of danger of injury: For trees six years of age and older of average or large size, ½ pint of 25 per cent emulsion; for trees six years of age and older of small size, ½ pint of 20 per cent; for trees four or five years old, ½ pint of 20 per cent; for trees three years old, ½ pint of 15 per cent; for trees two years old, ¼ pint of 15 per cent; for trees one year old, ⅛ pint of 7½ per cent emulsion.

It is suggested that the quantity be regulated rather closely, since excessive applications might cause tree injury. Ap-

Table 1.—Results of experiments with ethylene dichloride emulsion compared with paradichlorobenzene crystals for peach borer control in Georgia, New York and Illinois, September–October, 1937.

Treatment			Georgia		New York		Illinois	
Ethylene Dichloride Emulsion—Strength and Quantity per Tree	Paradichlorobenzene—Quantity per Tree	Number of Trees in Each Test	Total Borers	Per Cent Borers Dead	Total Borers	Per Cent Borers Dead	Total Borers	Per Cent Borers Dead
		Trees Six Years of Age or Older						
25%—½ pt.		10	18	100	19	100	78	100
20%—½ pt.		10	28	100	—	—	30	97
15%—½ pt.		5	20	95	22	100	—	—
	1 oz.	10	44	96	34	100	28	100
	No treatment	5	9	0	27	0	43	5
		Trees Five Years Old						
20%—½ pt.		10	59	100	8	100	13	100
15%—½ pt.		10	92	99	8	100	0	—
10%—½ pt.		5	37	70	—	—	—	—
	¾ oz.	10	31	94	19	100	21	95
	No treatment	5	21	0	108	3	35	0
		Trees Four Years Old						
20%—½ pt.		10	68	100	5	100	—	—
15%—½ pt.		10	39	95	7	100	—	—
10%—½ pt.		5	22	91	—	—	—	—
	¾ oz.	10	30	87	1	100	—	—
	No treatment	5	18	6	1	0	—	—
		Trees Three Years Old						
15%—½ pt.		10	22	95	18	100	—	—
10%—½ pt.		10	26	92	20	70	—	—
7½%—½ pt.		5	14	100	—	—	—	—
	½ oz.	10	28	82	6	67	—	—
	No treatment	5	14	0	10	0	—	—
		Trees Two Years Old						
20%—¼ pt.		10	16	100	16	100	5	100
15%—¼ pt.		10	11	100	11	100	3	100
10%—¼ pt.		5	6	50	—	—	—	—
	¼ oz.	10	11	100	4	100	0	—
	No treatment	5	11	9	3	0	5	0
		Trees One Year Old						
15%—⅛ pt.		10	21	100	—	—	—	—
10%—⅛ pt.		10	9	100	—	—	—	—
7½%—⅛ pt.		5	4	100	—	—	—	—
	⅛ oz.	10	13	77	—	—	—	—
	No treatment	5	9	0	—	—	—	—

Table 2.—Results of experiments with ethylene dichloride emulsion for peach borer control in New York in November, 1937, and in Georgia in December, 1936, to February, 1937.

TREATMENT		NEW YORK			GEORGIA		
Ethylene Dichloride Emulsion—Strength and Quantity per Tree	Paradichloro-benzene—Quantity per Tree	Number of Trees	Total Borers	Per Cent Borers Dead	Number of Trees	Total Borers	Per Cent Borers Dead
		Trees Six Years of Age or Older					
25%—½ pt.		19	98	100	5	41	100
20%—½ pt.		20	65	95	15	77	99
15%—½ pt.		—	—	—	5	42	98
	1 oz.	10	33	9	—	—	—
No treatment		5	14	0	5	25	4
		Trees Five Years Old					
20%—½ pt.		25	341	100	—	—	—
15%—½ pt.		20	264	100	—	—	—
	¾ oz.	10	89	6	—	—	—
No treatment		5	76	0	—	—	—
		Trees Four Years Old					
20%—½ pt.		20	15	100	4	3	100
15%—½ pt.		20	45	60*	30	63	100
10%—½ pt.		—	—	—	5	7	71
	¾ oz.	10	5	0	—	—	—
No treatment		7	2	0	1	13	7
		Trees Three Years Old					
20%—½ pt.		10	57	100	—	—	—
15%—½ pt.		20	41	100	5	5	100
10%—½ pt.		10	7	100	29	65	97
	½ oz.	10	47	13	—	—	—
No treatment		5	3	0	5	16	0
		Trees Two Years Old					
20%—¼ pt.		20	58	100	—	—	—
15%—¼ pt.		20	36	100	—	—	—
	¼ oz.	10	11	18	—	—	—
No treatment		5	7	0	—	—	—

* Live borers were very large and in the trunks far from the ground line. These trees were examined for borer control six days after treatment. The large borers might have been killed if the exposure to the treatment had been longer.

plications are made by wetting the soil immediately surrounding the tree; also the lower part of the trunk should receive some of the material during treatment. No preparation of the soil before treatment is necessary on loose, level ground. It is believed, however, that cupping the soil slightly toward the tree trunk to prevent the liquid from running off, and loosening the soil around the tree sufficiently to permit the liquid to be absorbed readily, will give better results in some cases. After the liquid has been applied, a little soil is placed against the trunk of the tree to prevent surface loss of the vapor. The treatment that is described here requires no later attention.—2-18-38.

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THE ALABAMA quarantine relating to the azalea disease which has been in effect since April, 1935, was revoked, effective October 20, as "no longer necessary."

Citrus Insect Projects of the Orlando Laboratory

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The projects of the Orlando, Fla., laboratory of the Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, have been organized and developed primarily to help solve the problems which confront the citrus growers of the Gulf states. Adequate and economical control of the insects and mites that attack citrus fruits is the ultimate aim. Importance of the various problems to the industry determines roughly the amounts of time devoted to each phase of the work, and the projects are kept flexible enough so that quick changes of emphasis may be made when advisable.

If the citrus insects and mites are listed according to their present importance to the grower, the citrus rust mite, *Phyllocoptes oleivorus* Ashm., takes first place. Then comes the group of scale insects, with the purple scale, *Lepidosaphes beckii* (Newm.), and the Florida red scale, *Chrysomphalus aonidum* (L.), most prominent. Next is the group of whiteflies, with the citrus whitefly, *Dialeurodes citri* (Ashm.), and the cloudy-winged whitefly, *Dialeurodes citrifolii* (Morg.), as the most important species. Then come the citrus red mite, *Paratetranychus citri* McG., and the six-spotted mite, *Tetranychus sexmaculatus* Riley, which are more sporadic in making appearances. Aphids, especially the green citrus aphid, *Aphis spiraecola* Patch, and the melon aphid, *Aphis gossypii* Glov., appear at times and are especially damaging to young trees. Mealybugs, *Pseudococcus citri* (Risso), sometimes become injurious on orange and, particularly, grapefruit trees. Following these more important pests there is a long list of other species which occasionally present control problems.

To the research worker, such a ranking of problems is just a general guide. He knows that the picture of today will change tomorrow, and that the changes will modify his program and present new lines of work for him to follow.

THE CITRUS RUST MITE.—Control of the citrus rust mite has been emphasized at the Orlando laboratory in recent years. The use of lime sulfur spray or sulfur dust long ago proved effective in commercial groves. Development of wettable sulfurs and their use with lime sulfur in sprays made possible the building up of heavier and more lasting sulfur deposits on leaves and fruit. With these heavier spray deposits there was the possibility of reducing the number of seasonal sprayings formerly necessary for prevention of russeting, and so lessening the costs of spraying. Experiments along this line showed that the addition of 5 pounds of wettable sulfur to 100 gallons of 2 per cent lime sulfur spray reduced the number of applications from three to two with early oranges, and from four to three, or five to four, with slow-growing varieties such as the Valencia. The savings, however, were not so great as expected, because of the cost of the wettable sulfur which was used.

ADHESIVES FOR WETTABLE SULFURS.—Used alone, wettable sulfur in quantities of 5 or 10 pounds per 100 gallons gave excellent kill of rust mites, but it was weathered away by rain and wind so fast that in protection against reinfestation it was inferior to lime sulfur. This led to trials of adhesive materials with wettable sulfur, in efforts to improve this feature. Gums of several kinds increased run-off of the spray mixture and were hard to mix with the spray water. Hydrated lime plus aluminum sulfate (3 pounds of each per 100 gallons) greatly prolonged the period of protection for each application, until results in controlling rust mites equaled those obtained with the spray of lime sulfur plus wettable sulfur mentioned above. Serious outbreaks of scale insects, however, followed the use of these two materials in double quantities (6 pounds each per 100 gallons of spray). During this season menhaden oil has been used with wettable sulfur with superior results from the standpoint of adherence, but further work is necessary to test its complete safety to fruit and foliage under all conditions.

DUSTING WITH SULFUR.—Even though five to eight dustings with sulfur may be necessary during a season as compared with two to five sprayings, the dusting method of control for rust mites has been

found satisfactory in experiments over several years, and is cheaper than spraying. The difference is not so much in cost of materials as in cost of application; dusting eliminates water procurement and spray mixing, and tree coverage is accomplished in much less time.

RECENT INFESTATION INCREASES OF SCALE INSECTS AND WHITEFLIES.—For several years scale insects and whiteflies of citrus have been on the increase. This is especially true of the Florida red scale, which has become a real problem for growers and entomologists. Control of this species is difficult, and information on its seasonal history or habits is not extensive. Because whiteflies resemble scale insects in habits and are controlled in much the same way, it has been practicable to combine work with them under the scale project.

The factors responsible for scale increases have been studied in a series of experiments. There is evidence to show that infestations follow the use of Bordeaux mixture and other sprays leaving heavy, inert residues on leaves and fruits. The beneficial scale fungus is affected adversely by the Bordeaux, and thus a natural check on scale increases is partly removed. Whether the residues from fungicidal sprays encourage scale insects by killing the beneficial entomogenous fungi which ordinarily check increase, simply furnish the scale crawlers better foothold for "settling" or exert influence in both of these ways, is still to be determined. It is definitely known, though, that increases in scale insect populations may result from presence on leaves and fruits of residues that are neither insecticidal nor fungicidal in nature. More extensive use of insecticidal sprays in efforts to produce fruit of better quality has increased the difficulty of controlling scales and whiteflies.

RAPID METHODS OF ESTIMATING INFESTATIONS.—Considerable time has been spent on methods of sampling leaves and fruits and of counting scale insects and whiteflies to determine infestation levels and trends. The method of spraying a tree or plot of trees, waiting three or four weeks, and then examining leaves with microscopes for kill of scale insects or whiteflies did not satisfy the requirements. A sampling procedure was needed which would permit rapid examination of samples of leaves or fruits, preferably without the use of microscopes—a method that would allow following infestation changes from month to month and year after year in a number of plots, and which would indicate the influence on these insects of a spray program rather than of single applications.

A method which satisfies these requirements has been worked out. Whenever information of infestation levels is desired, equal numbers of leaves are clipped from each tree of the plot, and 500 leaves, as a minimum, are examined with the unaided eye. These are tallied according to the scales found per leaf, in the following four groups:

1. Uninfested (with no scales).
2. Lightly infested (with 1–20 scales).
3. Moderately infested (with 21–50 scales).
4. Heavily infested (with more than 50 scales).

At harvest time fruits are handled in the same way. The method is applicable also to infestations of whiteflies. Usually no distinction is made between living and dead scales or whiteflies, on the theory that all were alive recently during the season. If, however, exact information on mortality is wanted, it is relatively simple to make supplementary examinations with microscopes for that purpose.

SCALE CONTROL WITH LIME SULFUR AND OIL EMULSION SPRAYS.—A number of experiments have been conducted to determine whether several sprayings each year with lime sulfur plus wettable sulfur would control scales and whiteflies so that the use of oil emulsions could be eliminated entirely. So far, when Bordeaux spray was used in the program later than February, scale insects and whiteflies increased in spite of the sulfur sprays which were applied primarily for control of rust mites. For light scale infestations the possibilities are still being investigated, but for heavy infestations, and for the Florida red scale particularly, oil emulsion spray has been needed for satisfactory control.

THE FLORIDA RED SCALE.—For nearly two years the seasonal history of the Florida red scale has been followed by making examinations of large numbers of the insects at two-week intervals. Records have been kept of living and dead scales, of each of the developmental stages, and

of stages destroyed by the scale fungus or parasites. It has been found that there are two peaks of reproductive activity, in March–April and in July–August. The information obtained so far suggests that spraying with oil emulsion during the first reproductive peak might be better for control than spraying later in the year after the scales have become more numerous and damage has been done. The first type of spraying is being tried in a plot of 132 grapefruit trees.

FRUITFLY BAIT SPRAYS.—In the work at Key West with the West Indian fruitfly, involving two species, *Anastrepha acidusa* (Walk.) and *A. suspensa* (Loew) (McAlister 1936), carried on cooperatively by a Bureau laboratory and the State Plant Board of Florida, an improved bait spray was developed. This was a molasses-water mixture containing tartar emetic as the poison. After its effectiveness for control had been demonstrated at Key West and by Bureau laboratories outside of continental United States, arrangements were made with the Bureau of Plant Industry and the Bureau of Chemistry and Soils to test the physiological effects of repeated use of this spray on citrus trees and fruit in Florida and Texas.

The Orlando laboratory has made regular applications of this bait spray to plots of orange and grapefruit trees every 10 or 20 days for more than two years, and to date some trees have been sprayed 90 times. Bureau of Plant Industry workers measure tree growth, leaf production and fruit enlargement, and watch for signs of damage. Early in the work, when heavy applications of a "washing" spray were put on in periods of scant rainfall, spray burn on fruit was experienced. To avoid this effect, the "droplet" method of spraying was adopted, in which only 5 or 6 pints of bait spray are applied to each tree in "spatters" or droplets. The Bureau of Chemistry and Soils has made analyses of juices from sprayed and unsprayed fruits to study variations in the solids/acid ratio which might be attributed to the sprayings. The present indications are that the tartar-emetic bait spray might be used safely on citrus trees with the droplet method, if fruitflies were to gain entrance to the main citrus areas of the Southeast. It has been arranged to continue this cooperative experiment for a full five-year period, to obtain a variety of seasonal conditions that a shorter period would not afford.

MISCELLANEOUS WORK.—Time and space here are too limited to permit full discussion of the work done on a number of the minor pests. Mention might be made that satisfactory control of the citrus red mite was obtained by spraying in June with oil emulsion. A preliminary study of the "little fire ant," *Wasmannia auropunctata* Roger, in its relation to citrus insects has brought forward a number of interesting points. We are particularly interested in problems that have more than a local application.

The Orlando laboratory is fortunate in being located where there is a group of research workers of the Department of Agriculture whose fields of investigation are closely allied. Cooperative approach to solutions of mutual problems is thus possible, and has been utilized in several instances. Helpful contacts with state workers are also frequently made. Since the laboratory is a fact-finding unit rather than a service or information-distributing organization, it has limited its efforts strictly to its field of research.—2-18-38.

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STATE ENTOMOLOGIST J. Carl Dawson of Missouri has requested that his state be removed from the tomato pinworm quarantine placed by Colorado, Idaho, Montana, Oregon, Utah and Washington. Strict quarantine regulating the movement of tomato plants and fruit was instituted by the above states when tomato pinworm was discovered in a large vegetable-growing greenhouse in St. Joseph, Mo., in 1934. A survey carried on in 1936 disclosed no infestation in Missouri other than that in the St. Joseph greenhouse. In February, 1937, an effort to eradicate the tomato pinworm was made in this greenhouse. Since February, 1937, 12 careful inspections of the greenhouse and inspections in the general area of the greenhouse have failed to reveal a single specimen of this insect, according to State Entomologist Dawson, who believes that the tomato pinworm has been eradicated from Missouri.

Effect of Spray Residues on Scale Insect Populations

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General observations over a period of several years in Florida have indicated that accumulations of road dust and residues from insecticidal and fungicidal sprays and dusts on citrus foliage and fruit are at times responsible for an increase of scale insects. It is believed that the presence of these inert residues on leaves and fruit enables the young scale crawlers to become established by protecting them from direct sunlight and heat or by affording them a foothold among the residue particles.

THE PROBLEM.—In an experiment for control of the citrus rust mite, *Phyllocoptes oleivorus* Ashm., during 1936, on orange trees of the Parson Brown variety, confirmation of this theory was obtained. Essentially, this experiment was a comparison of the control of the rust mite by the use of eight different combinations of lime sulfur or wettable sulfur, with and without adhesive materials. For some plots the amounts of the adhesives were doubled, which caused heavy residues to be left on the leaves and twigs. There was an unsprayed plot of trees for comparison. In the laying out of the plots, the 108 trees of the block were divided into small groups of three trees each. Each spray mixture was applied to four well-separated groups, or 12 trees in all, either two or three times during the season, as needed for adequate control of the rust mite.

During the winter of 1936–37 the infestations by the purple scale, *Lepidosaphes beckii* (Newm.), and the Florida red scale, *Chrysomphalus aonidum* (L.), were noticeable on all trees that showed considerable residue. Leaf samples from sprayed and unsprayed trees were collected in February, 1937. A method of sampling was used by which 640 leaves

Table 1.—Scale populations found on sprayed and unsprayed leaves and fruit.

Plot No.	Treatment		Number of Applications in 1936	Scale Insects on 160 Leaves Feb., 1937	Per Cent of Fruits With More Than 50 Scales Each Oct., 1937†
	Insecticide*	Adhesive*			
1	None (check)	None	0	3,956	24.6
2	Lime sulfur‡ 2 gal.	None	3	4,621	28.3
3	Lime sulfur 2 gal. Wettable sulfur 10§ lb.	None	2	5,053	27.6
4	Lime sulfur 2 gal.	Rosin residue emulsion 3 lb.	2	5,574	34.3
5	Lime sulfur 2 gal.	Hydrated lime 3 lb. Aluminum sulfate 3 lb.	3	6,086	44.3
6	Wettable sulfur 10 lb.	Rosin residue emulsion 3 lb.	3	6,473	39.2
7	Wettable sulfur 10 lb.	Hydrated lime 3 lb. Aluminum sulfate 3 lb.	2	7,074	38.0
8	Lime sulfur 2 gal.	Hydrated lime 6 lb. Aluminum sulfate 6 lb.	2	12,391	55.3
9	Wettable sulfur 10 lb.	Hydrated lime 6 lb. Aluminum sulfate 6 lb.	2	26,633	51.5

* Per 100 gallons.
† Samples of 600 fruits each; 50 per tree.
‡ Baumé 32°.
§ Ten per cent inert ingredients (conditioner, blood albumin, and wetting agent).

were obtained from each plot, and from these a sample of 160 leaves, chosen at random, was examined. The total number of scales found in each sample is given in table 1.

EFFECT OF SPRAY RESIDUE ON SCALE POPULATIONS.—During the growing season of 1937 the scale insects continued to increase, although residue-leaving sprays were not used. At harvest time, October, 1937, scales were so plentiful on the fruit that samples of 600 fruits from each group of trees sprayed with different materials and the same number from the unsprayed trees were examined to determine the number of scales present. The percentage of fruit in each sample showing 51 or more scale insects is included in table 1.

The plots are listed in the table according to the visible residue present on leaves in February, 1937, from the least to the greatest. Scale infestations were heaviest on leaves showing the most spray residue. On a sample of 160 leaves from plot 2 (sprayed only with lime sulfur, 2 gallons per 100 gallons of water) 1.17 times as many scales were found as on the same number of unsprayed leaves. The number of scales found on leaves from plots 3, 4, 5, 6 and 7 increased slightly, until 1.79 times as many scales were found on leaves sprayed with wettable sulfur 10 pounds, hydrated lime 3 pounds, aluminum sulfate 3 pounds, per 100 gallons of water, as on the unsprayed sample. Leaves from plot 8, treated with lime sulfur 2 gallons, hydrate l lime 6 pounds, aluminum sulfate 6 pounds, per 100 gallons of water, showed approximately three times as many scales as the check, while the sample of leaves sprayed with wettable sulfur 10 pounds, hydrated lime 6 pounds, aluminum sulfate 6 pounds, per 100 gallons of water (plot 9), contained 26,633 scales, or nearly seven times the number found on the unsprayed leaves.

In table 1 it will be seen that mixtures of wettable sulfur and adhesives built up somewhat higher scale insect populations than corresponding mixtures in which the insecticide was lime sulfur. For example, plot 7 (wettable sulfur plus hydrated lime and aluminum sulfate) with 7,074 scales per sample, may be compared with plot 5 (lime sulfur plus the same adhesives in equal quantities) with 6,086 scale insects per sample; or plot 9 (wettable sulfur plus the same adhesives in double quantities) with 26,633 scales, as against plot 8 (lime sulfur plus double quantities of adhesives) with 12,391 scale insects per sample. The wettable sulfur used in this work contained blood albumin, conditioner and wetting agent, which undoubtedly added to the residues on the leaves, as well as increased the adhesive properties of the spray.

EFFECT OF SULPHUR ON SCALE POPULATION.—All of these sprays contained large quantities of sulfur, which is considered to be somewhat effective in killing scale crawlers. The treatments were applied primarily for the control of the rust mite, but some applications were made at a time when many scale crawlers were present. It is possible that the scale increases took place after the insecticidal qualities of the various spray mixtures had been dissipated and only nontoxic residues remained. No harmful effects of the sulfur materials on scale crawlers or other stages of the insects can be seen in the infestation results. If there was any mortality of scales from the sprays at any time during the year, the effect must have been transitory and slight and was obscured later by increases of scale insects in the sprayed plots.

The results at harvest time in 1937 showed that plots 8 and 9 had 55.3 per cent and 51.5 per cent, respectively, of the fruits heavily infested with scales. Samples of fruit from the remaining treatments were infested to a lesser extent, but the fruit from all trees sprayed in 1936 showed a heavier infestation than fruit from unsprayed trees. It should be remembered that these fruits had not received any residue-leaving sprays during the entire time they were being produced, but were attacked by the progeny of scales developed on leaves and branches the previous season. These fruit-infestation records show that heavy-residue spray mixtures may bring about scale population increases the second year.

CONCLUSION.—It is obvious that, in endeavoring to prolong the effectiveness of sulfur sprays used for the control of citrus rust mites, adhesive materials which may leave heavy, inert residues should be avoided, because of increases in scale insect population that might follow their use.—2-18-38.

Control of the Poinsettia Root Aphid

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The poinsettia root aphid, *Pemphigus* sp., was first reported to the Department of Entomology, December 1, 1937, as infesting practically mature poinsettia plants in a greenhouse at Ardmore, Okla. A visit to this greenhouse showed that only part of the plants was infested, the heaviest infestation being found on the larger plants and those which were potted during September and early October. None of the infested plants showed any signs that would lead one to believe the aphids were causing injury.

Habits.—The aphid as found on poinsettias is subterranean and apparently feeds only on the roots. It is pale yellowish green, usually surrounded by a cottony material and at times is itself partially covered with it. The aphids are so sluggish that it is necessary to make close observations to detect their movements. In potted plants, they are found infesting the roots that seem to be most easily accessible, or those near the outer side of the earth ball which is in direct contact with the sides of the pots. They are also found infesting the roots where they have grown into small cavities that were left in the soil while the plant was being potted. Where the plants are growing in benches, the roots are infested only where the soil has cracked and the roots have either grown into or across these cracks. In no instance was an infestation found where the soil was tightly packed around the roots.

The infestation at Ardmore did not come to the attention of the Entomology Department until the poinsettias were almost mature. This made any attempt at controlling the insects more difficult because the plants at this stage of development are very sensitive to any unusual treatment. Because of this, the control experiments had to be conducted on a rather small scale to avoid destroying any large number of plants. Seven different treatments were tried in which nicotine sprays and dusts, a rotenone dust, a cyanide paste and hot water were used. Each of these tests is discussed separately in the following paragraphs.

Materials and Procedure.—The first treatment consisted of watering the plants with a *Black Leaf 40*, water and soap solution. The preparation was made up of one ounce of strong soap solution, five tablespoonfuls of *Black Leaf 40* and one gallon of water. The plants were watered with this solution at the rate of one pint to a plant in a 5-inch pot. The following day, or 30 hours after treatment, two of the plants were examined, at which time it was evident that a control of not over 50 per cent had been obtained. They were then given a second treatment, but this time the solution was heated to a temperature of 100 degrees F. An examination of the plants 10 days later again showed that the treatment gave no better than 50 per cent control.

Powdered cubé root with a 5 per cent rotenone content was used on another group of the plants. The treatment consisted of bumping the earth balls and plants out of the pots, following which the dust was applied to the roots and inner sides of the pots by means of a salt and pepper duster made by punching holes into the lid of a mailing tube. The plants were treated about 11 a.m. and examined again at 5 p.m. the same day, at which time a kill of not over 50 per cent was found. The following day, or 24 hours later, they were again examined, but apparently there was no greater kill. Examination of these plants 10 days and 17 days later showed them still to be as heavily infested as they were one day after treatment.

Cyanogas G grade dust made into a thin paste with linseed oil gave 100 per cent kill when the insides of the pots were painted with it. This treatment was, however, so severe that the foliage of the treated plants began to curl within three hours after treatment.

It was thought that treating the plants with hot water might be an effective control if the high temperature was not injurious to them. In order to determine the effectiveness of hot water live aphids were placed in a glass vial. The unstoppered vial was next partially submerged in a pan of water that had previously been heated to a temperature of 115 degrees F. The application of heat in this manner killed the aphids in less than 10 minutes.

Several potted plants were then placed in a pan of water that had previously been heated to this temperature. A thermometer was placed in the center of the pot and watched until it reached the same temperature as that of the water. This temperature was then maintained for five minutes, after which the pots were removed, the excess water drained off and the plants labeled and returned to the regular place on the bench of the greenhouse. The plants were treated as described at 9:30 a.m. on December 3, 1937. At 4:30 p.m. of the same day they were examined and found to be in excellent condition, but the aphids were all dead. The following day the plants were again examined. Not a single live aphid was found and the plants were still in excellent condition. The plants were cared for in the regular manner and when again examined, December 13, 1937, the outside roots had turned brown and had begun to decay. A few of the lower leaves had begun to turn yellow, but no live aphids were found. When again examined, December 22, 1937, the plants were still alive, but one third of the lower leaves had dropped. Most of the roots adjacent to the pot were dead, but new root development had begun to appear near the center. At this time the roots were cut off and the tops sold as cut flowers instead of potted plants.

Nicotine dust of approximately 5 per cent strength, with hydrated lime as the carrier, showed promise of giving effective control though it caused some root injury. Treatment consisted of dusting the earth ball and inside of the pots. The five plants treated in this manner were examined six hours after treatment and no live aphids were found. The following day only two live aphids were observed on the five plants that were treated. Nine days later the plants were still in good condition and only two of the treated plants were found infested. On one of these the infestation was near the surface of the soil in the pot, adjacent to a partially decayed straw that was projecting above the surface; so it could easily have been reinfested from the nearby plants.

The following formula gave good control:

Lemon oil	5 tablespoons
Black Leaf 40	2 tablespoons
Ivory Soap	1 handful
Water	3 gallons

The solution was first heated to a temperature of 110 degrees F. The plants were next bumped loose in the pots so that the ball of earth remained attached to the plant roots. The pots and plants were then submerged in the heated solution; then the plants were partially lifted out of the pots so that the liquid flowed freely around the outer roots. While still submerged the plants were allowed to settle back into the pot and remain there for a few seconds, or until most of the air bubbles had come from the soil to the surface. The excess liquid was next poured off and the plants returned to the benches. Ten of the plants in this treatment were examined four days later, but only one live aphid was found. Five of the plants showed very definitely that they had been infested by this aphid.

The last treatment was also successful. The solution used was made up as follows:

Black Leaf 40	5 tablespoons
P. & G. Laundry Soap	¼ bar
Water	5 gallons

This mixture, like the previous one, was heated to a temperature of 110 degrees F. and the treatment of the plants was the same as the above. Ten of the treated plants were examined four days later. Only one of the 10 was found infested at this time. On this one plant a colony of three live aphids was found. No injury was observed on plants treated with the above two formulas.

SUMMARY.—Seven soil treatments were tested to determine their efficiency in controlling the poinsettia root aphis. Three of the treatments showed promise. Dusting the earth ball and inside of the pot with a 5 per cent nicotine dust gave good control with little root injury. Loosening the earth ball and submerging it in a solution of lemon oil, *Black Leaf 40*, soap and water which had been previously heated to 110 degrees F. gave good results. A similar treatment in which the lemon oil was omitted gave as good results.—9-14-38.

Factors Influencing Insect Abundance

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The advancement which has been made in the fields of insect physiology and ecology is encouraging to all entomological workers. Unquestionably many of our future successes against the Hexapods will have a foundation in physiological and ecological principles. If we think of insects as chitinous test tubes which are filled with compounds of a chemically complex nature and surrounded by other organisms of great complexity we immediately visualize the astounding perplexity of the study of entomology.

The biotic and physicochemical environments consist of many factors that play no little part in the well-being and continuance of species. These factors are constantly changing, and as a result life is changing. When man enters the picture, he tends to speed up or slow down nature's slow but never-ending progress. Man's activities are usually designed to facilitate man's progress; but in many cases they have resulted in his degradation. Modern progress demands too much speed without due consideration to stability and permanence.

In the field of agriculture, with the aid of science, the layman has made what is termed phenomenal progress. Doubtless many errors have been made, because of undue stress being placed upon activities that are not entirely based upon facts. Entomology has been closely linked with man's economic and social progress; in fact, insects and their near relatives are the most important limiting factor to the economic production of plant and animal crops, and to the health and happiness of the human race.

It is only natural then that vast sums of money have been set aside for the scientific study of the complex units in our biotic and physicochemical environments. Insects, as one of the most important phases of these environments, have been brought under careful scrutiny. Unquestionably they exert a profound effect upon other occupants of the earth's surface. They have been studied from many angles such as their anatomy, biology, taxonomy, ecology, physiology and control.

During the last 114 years, the economic entomologists have attempted detailed studies concerning the effects of insects upon other organisms, both plant and animal. As yet we have not given much attention to the effects of various environmental factors upon insects. This phase of our work is now stepping into the spotlight and it does not take an ecologist or physiologist to appreciate its ultimate value. It behooves all entomologists to encourage the careful study of economic insect physiology and ecology.

Agriculture has changed much since colonial days. With the extreme changes in crop production have come an intensification of insect attack and apparently an enormous increase in insect abundance. As a result of this increased abundance and its resultant injury, man has developed potent chemicals and chemical disseminators that give him an immediate annual reduction in insect numbers, and a partial protection of his crops. Our successes in our chemical warfare with insects are heartening to all applied entomologists. However, it would take a scientist with the vision of a worm not to realize that we need to concentrate our attention upon studies that tend toward permanency. The greatest curse of modern science is that in general it is supported by funds that are supplied by agencies that demand annual displays of sensational advances. Nature does not submit to man's conquering forces so easily. It will take years, even scores of years, to align nature's forces in trenches against the impending and destructive forces of insects. The careful study of nature's controlling forces is essential; therefore natural and biological control must be given an opportunity to contribute.

INSECT DIET AND REPRODUCTION.—The diet of various animals unquestionably affects their vigor and thereby their reproductive ability. During investigations with *Dysdercus suturellus* (H. S.) and *Alabama argillacea* (Hbn.), the author noted striking effects of diet deficiency upon the general vitality of these species and the prolificacy of the females.

In the case of *A. argillacea*, adults were obtained from field-collected pupae.

Emerging adults were placed in large stender dishes. Fresh cotton leaves and pieces of apple were added. The adults fed heavily upon apple and other fruits. Under this condition the author discovered that the females may deposit 1,300 to 1,500 eggs. Larvae obtained from these eggs were kept in confinement, and the resulting adults were used in obtaining eggs for another brood. It was observed that after being handled in this manner for a period covering seven or eight broods the adult females decreased in prolificacy and size. In fact the marked decrease in the number of eggs produced by each female tended toward complete extermination. Breeding cages were then set up in order to increase the adults' vitality. These were screen-wire cages. Large numbers of flowers were collected and placed in the cages. Branches of cotton plants were added. Approximately 25 males and 25 females were added to each cage. Cotton leaves were removed daily, and fresh leaves supplied. The adults fed heavily upon the nectar of the flowers, and the immediate effect was to restore them to their normal reproductive capacity. The above data indicate the potent part that wild and cultivated flowers may have upon the increase or decrease of insect populations. The author has observed similar reproductive responses in *Pontia rapae* L. and other species.

Pairs of adult cotton stainers, *Dysdercus suturellus*, in the act of coitu, were collected in the field. These were brought to the laboratory and placed in individual stender dishes. This procedure was followed in order to determine the number of eggs deposited by each female. The average number deposited by field-collected adults was 92.

Laboratory plants were grown in large wooden tubs. When they reached a height of 1½ feet they were covered with an inverted bell jar which was covered with cheesecloth. A group of 200 nymphs was transferred immediately after eclosion. Their entire life was spent upon these small plants. In many cases their presence upon the plant resulted in the death of the plant due to the abnormal quantities of salivary juices which were injected. After reaching maturity the adults were separated into pairs and placed in individual stender dishes, where they were fed upon fresh cotton leaves. The average number of eggs produced by these females was 26. Continued rearing upon laboratory plants eventually resulted in dietary reproductive inhibition.

Adult and nymphal cotton stainers may frequently be seen feeding upon green cotton bolls or old cotton seed. The author therefore removed some laboratory reared adults from the bell jars and placed them in stender dishes containing fresh bolls, and old cotton seed. The prolificacy of the females was returned to normal and the number of eggs produced ranged from 85 to 130. These data tend to substantiate the author's belief that the food of adult Heteroptera will tend to affect their reproductive capacity and thereby their abundance.

DEFICIENCY DISEASES OF PLANTS AND VERTEBRATE ANIMALS.—During recent years we in Florida have become somewhat soil-deficiency conscious. This has been due to some rather startling discoveries relative to the effect of the absence of certain so-called trace elements upon plant and animal normalcy. Thus the bronzing of tung oil trees has been proved to be the result of a soil deficiency of zinc; the frenching of citrus to a zinc deficiency; the everglades chlorosis of beans to a manganese deficiency; and "salt sick" of cattle to an iron and copper deficiency. The addition of the necessary element to the soil or the animal or plant was found to be a corrective.

EFFECT OF SOIL DEFICIENCIES UPON INSECTS.—There are many things pertaining to the virulence and abundance of parasitic organisms that we are unable to explain by means of the data that we have obtained by our modern scientific approach. Bacteriologists have found that certain organisms become exhausted after being cultured on certain media over a period of time. We know that the injury produced by many fungi is more severe in certain areas, and on certain soil types, than on others. We are likewise well aware of the fact that some species of insects are exceedingly injurious in some areas while remaining non-injurious in others, though they have ample and unimpeded methods of distribution. In many cases the strength or impotence of insects may be explained by weather, climate, topographical factors, predators, parasites and insect diseases. Yet, there are cases in

which these explanations are inadequate. In such cases the explanation might well be found in elemental deficiencies or variations.

Insects are very plastic, being materially influenced by various factors in their environment. Because of their parasitic nature they are influenced markedly by the condition of the host. The obligate species would naturally be affected more violently physiologically by certain host up-sets than the more facultative species. Does it not seem logical that a careful analysis of the composition of soils, of the plants that grow upon these soils, of the animals that feed upon these plants and of the insects that are parasitic upon these plants and animals might throw a brilliant light upon insect severity and abundance; a light that might contribute much to our abilities to control the more economic species? Such an analysis might be made by chemical methods or with the spectroscope.

The author has conducted laboratory tests in an effort to show the relationships between the composition of soils and insect abundance. An obligate Lepidopterous species, *Alabama argillacea* (Hbn.), was used.

METHODS OF TESTING EFFECTS OF SOIL DEFICIENCIES.—The plants used were grown in a sand culture prepared as follows. Six-gallon crocks were filled with white builders sand. The sand was washed in 15-gallon crocks; tap water followed by a distilled water rinse, was used. After being washed, the sand was placed in sterile crocks, and in the upper surface of the sand the seed were placed. Sixteen crocks were prepared. Knop's complete nutrient solution less one major element plus the trace elements, manganese, copper, boron, barium, arsenic, iodine, aluminum and iron, were added to seven of the crocks. Seven of the remaining crocks received Knop's complete culture solution plus six of the trace elements, each crock being deficient in one trace element. One crock received only Knop's complete culture solution. Plants were furnished nutrients on the basis of a molar solution of the major elements and five parts per million of the trace elements.

DISCUSSION OF SOIL DEFICIENCY TESTS.—The author was more interested in the effects of trace element deficiencies than in major element deficiency. At first experimentation was concentrated upon the copper and zinc deficient plants. The results were striking and interesting.

Caterpillars were transferred to the foliage of copper and zinc deficient plants immediately after eclosion. Hundreds of larvae were used in the tests. The larvae used as checks were placed upon leaves which were taken from plants growing in a sandy loam soil.

The mortality rate of the larvae feeding upon zinc and copper deficient foliage was exceedingly high. In the case of the former the average mortality was 92 per cent and in the latter 90 per cent. The mortality rate of the check larvae was 8 per cent. In the majority of tests the larvae died during the first and second stadia.

The general appearance of the larvae that were capable of surviving on copper and zinc deficient foliage was very different from that of the check larvae. The larvae fed the chemically deficient diet were of a reddish to reddish-brown color, as compared with the typical green of normal caterpillars, and during the late larval stadia voided from the mouth quantities of a reddish-brown secretion. The filter papers in the bottom of the rearing dishes were usually heavily spotted.

Though larval mortality was exceedingly high, some 8 per cent of the larvae on the diet deficient in zinc reached the pupal stage. However, they required an average of 24 days to complete the larval stage as contrasted with 14 days for larvae fed upon normal tissues. This increased time requirement for a complete life cycle plus the high mortality would definitely affect the abundance of the species. For example, the average lengths of time spent in the various stages by normal individuals are, egg stage, 3.5 days; larval stage, 14 days; pupal stage, 8.8 days; from emergency to oviposition, 5 days. The complete life cycle of normal individuals requires 31.3 days. Assuming that the stages other than the larval stage would be the same for deficient larvae, the complete life cycle would require 41.3 days for larvae fed on zinc-deficient plants and 38.8 days for those fed on copper deficient plants. In Florida the test species normally has seven broods. Under the same conditions larvae feeding on zinc deficient plants would be capable of completing only four or five broods.

The reproductive potential of normal individuals is high. The adult female deposits approximately 1,300 eggs. Assuming that one half of the resulting larvae would produce virulent females and that they would in turn produce 1,300 eggs each, we may assume that a normal seven-brood year would result in the production of 93,991,349,998,691,990,495 individuals from a single female. The biotic potential of this same species with only a zinc deficiency limiting factor would be very different. Contrasted with the reproductive potential, a single female whose progeny was fed upon zinc deficient foliage would result during a normal four brood year in the seasonal production of 21,555,488 individuals, or a difference of 93,991,349,998,670,432,007. The author found that continued feeding upon deficient plants, for several broods, resulted in elemental castration of the females.

Zinc and copper deficient plants were not the only ones that gave positive results. In fact, several of the deficient plants were entirely incapable of meeting the nutritional requirements of the larvae. The author after continued investigation will present more complete data.

OBSERVATIONS.—An extreme variation in the composition of the soil usually results in a definite observable change in the plants occupying the soil. However, it is doubtless true that many soils may be slightly to moderately deficient in elements, especially trace elements, without producing a striking variation in the general appearance of the plant occupants. What effect this physiological condition might have upon insects and vertebrate animals is not known. A careful study of nutritional and elemental deficiencies in insects might facilitate deficiency studies in domestic animals and even in man. It is certainly true that several species of insects would doubtless react differently to the same physiological change. For example, the presence of a certain element in quantity might deter the attack of some insect species and stimulate attack by others. The author noted that the zinc and copper deficient plants seemed to meet the requirements of mealybugs and certain species of aphids.

Plant medication as a means of insect control is exceedingly old. The application of some chemical material to the soil, the trunk, branches or foliage of plants in an endeavor to destroy injurious species of insects has been attempted for many hundreds of years. Plant medication has been an utter failure in all but a few cases. There has been some experimental work that tended to prove that the absorption of copper and other compounds resulted in the production of cell sap that was toxic to leafhoppers, etc. These materials at the same time did not seem to influence attack by other injurious insects and arachnids. Plant medication as an immediate control will always be limited; but the application of chemicals as a long-range means of reducing insect populations may be a worthy phase of entomological investigations.

In Florida we have a fungus complex. In certain quarters it constitutes heresy even to raise the question of the possibility of insectivorous fungus ineffectiveness. We have many fungi and bacteria that are of apparent value, and certainly some of questionable value. For example. *Empusa fresenii*, a fungus affecting *Aphis spiraecola* Patch is certainly a beneficial form. The bacteria that is so effective in the destruction of *Autographa brassicae* (Riley) is another organism of value. Likewise *Aschersonia aleyrodis* upon the citrus whitefly, *Dialeurodes citri*, Ashm., is doubtless a very effective control that nature has provided. However, the author has failed to uncover a single paper that treats of the pathogenic relationship between red aschersonia and the citrus whitefly. Neither has he been able to discover a single technical paper clearly proving the beneficial value of other so-called beneficial fungi that theoretically prey upon other citrus pests. Many of these fungi are doubtless saprophytic. The majority of the reports relative to the beneficial effects of the fungi occurring in citrus groves have been based upon individual observations and not on scientific experimentation. The author in no way states that they are not of value, but merely indicates that detailed tests would be worthy. At present we are endeavoring to prove or disprove the pathogenic relationships between fungi and citrus pests.

For many years it has been observed that the normal application of Bordeaux mixture for the control of citrus diseases apparently affects the populations of scale, citrus whitefly, etc. It has generally

been assumed that the abnormal increase is due to the destructive effect of the copper upon beneficial fungi. Nevertheless, scientists have not proved the case. It is within the realm of possibility that the absorption of copper by the plant may produce a physiological change in the plant protoplasm which may be conducive to the increase of certain insect populations. The author has incomplete data that would tend to prove that the application of certain materials to plant foliage may result in a physiological change in the protoplasm of the plant that results in the destruction of certain species and stimulates the activities of others to such a degree that an eventual increase of populations results. A long-range study of the effects of spray applications upon insect abundance should prove to be a worthy one. Certainly the indiscriminate applications of spray materials and fertilizers will eventually be discontinued. The author has instituted tests that should tend to demonstrate the effect of certain sprays and fertilizers.

This treatise should be considered as a progress report. As additional data are obtained the facts will be published.

SUMMARY.—Feeding experiments have indicated that diet deficiency affects the general vitality of insects and the prolificacy of the females. Tests made by the author indicate that elemental deficiency or variation may likewise materially affect the prolificacy of females. The so-called trace elements were given particular attention.

Tests indicate the possibility of a long-range effect of elemental absorption upon insect populations. This absorption may be directly through the leaf surface or by way of the root system. Indications are that in many cases insect population increase following fungicidal applications may be due more to a physiological change in cell sap than to a destruction of beneficial fungi.—8-8-38.

Experiments on the Control of the Velvetbean Caterpillar, *Anticarsia gemmatilis* (Hbn.)

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The velvetbean caterpillar, *Anticarsia gemmatilis* (Hbn.), has been known for many years as a pest of velvet beans in several of the southeastern states. More recently, it has attracted the attention of the entomological workers in that section as a pest of soybeans and peanuts as well. It was not until 1929 that this tropical species appeared in destructive numbers in Louisiana. The preference of this species for soybeans was demonstrated by both Hinds (1930) and Douglas (1930), who noted that velvet beans grown adjacent to soybeans were not harmed, although the soybeans were defoliated by the caterpillars. The present writers have made the same observation during the past two years.

Since 1929, *Anticarsia* has appeared yearly in fields of soybeans in the southern half of Louisiana, and in years of heavy outbreaks the seed crop has been largely destroyed due to the complete defoliation of the plants by the caterpillars. In view of the damage caused by this insect, an investigation was begun in the fall of 1936 for the purpose of studying it under conditions in Louisiana and of developing possible measures of control.

During the course of this investigation, extensive laboratory and cage tests were made on various safened samples of calcium arsenate, on several fluorine insecticides and on various organic stomach-poison insecticides.

From the results of these preliminary studies, several materials were selected for field experimentation. In this paper are given the results obtained with these materials in 1937 for controlling the caterpillars on soybeans grown for seed production.

MATERIALS.—A neutral, finely ground, synthetic cryolite applied straight and mixed with 1, 2 or 3 parts of talc, which was especially prepared for dusting purposes, was used in one or more of these experiments. Two safened calcium arse-

nates, designated as numbers 1 and 2, were used in three of the experiments. Sample number 1 was a basic calcium arsenate which contained 41.30 to 42.05 per cent As_2O_5 and 0.50 to 0.66 per cent water soluble As_2O_5 (Geneva method). To this was added a corrective in order to make it safer on soybean foliage. The final admixture contained 33 per cent As_2O_5. Calcium arsenate sample number 2 contained 40 per cent As_2O_5, 8 per cent $ZnSO_4$, 0.1 per cent water soluble As_2O_5 (Geneva method) and 5 per cent free $Ca(OH)_2$. The original calcium arsenate to which the $ZnSO_4$ was added was a basic type.

EXPERIMENTAL PROCEDURE.—Four field experiments were conducted and to facilitate the presentation of these data, they have been designated 1, 2, 3 and 4. Experiments 1 and 2 were located three miles south of University, La.; experiment 3 at St. Gabriel, La.; and experiment 4 at the Louisiana Penal Farm at Angola, La. The beans were planted in alternate hills with corn in 4½-foot rows. The insecticides were applied, when the foliage first began to show signs of injury by the caterpillars, with *Niagara* rotary hand dust guns, either early in the morning while the plants were wet with dew or late in the afternoon while there was very little air movement. No rain fell for at least 24 hours after application of the insecticides. In all cases the caterpillar infestation was very uniform in the plots of a given experiment. The soybeans in experiments 1, 3 and 4 (with the exception of one plot of edible beans) were of the 0-too-tan variety, and the vines had completely covered the ground at the time the insecticides were applied. In experiment 2, the soybeans were of the Avoyelles variety. They were planted about July 1, and were only about 12 inches in height when the insecticides were applied. The test plots were at several locations on the farm in experiment 4, and an untreated strip adjoining each test plot was left as a check. The insecticides in experiment number 1 were applied on August 15; in experiment number 2 on August 26; in experiment number 3 on August 31; and in experiment number 4 on September 10–13, inclusive.

Table 1.—Results from insecticides used as dusts in field tests on velvetbean caterpillars, 1937.

Experiment No.	Treatment	Size of Plot, Acres	Rate of Application, Pounds per Acre	Insecticidal Injury to Bean Plants	Estimated Per Cent Defoliation	Estimated Per Cent Normal Seed Crop
1	Cryolite	1.0	10	None	5	100
1	Calcium arsenate no. 1	1.0	6	Moderate	10	70
1	Calcium arsenate no. 2	1.0	10	Severe	5	50
1	Check	1.0	—	—	100	0
2	Cryolite	0.5	9	None	5	100
2	Cryolite ½, talc ½	0.5	12	None	10	100
2	Cryolite ¼, talc ¾	0.5	15	None	15	100
2	Calcium arsenate no. 1	0.5	13	Severe	5	70
2	Calcium arsenate no. 2	0.5	8	Severe	5	70
2	Check	0.5	—	—	50	80
3	Cryolite ½, talc ½	1.0	14	None	5	100
3	Cryolite ⅛, talc ⅞	1.0	15	None	10	100
3	Calcium arsenate no. 1	1.0	6	Slight	10	95
3	Calcium arsenate no. 2	1.0	6	Slight	10	95
3	Check	1.0	—	—	60	70
4*	Cryolite	10.0	9	None	5	100
4	Cryolite ½, talc ½	35.0	16	None	5	100
4	Cryolite ⅓, talc ⅔	11.0	13	None	30	90
4	Cryolite ¼, talc ¾	9.0	15	None	30	90
4	Check	5.0	—	—	100	0

* This was a plot of edible soybeans planted in 3-foot rows.

RESULTS.—The results of these experiments are given in table 1. The estimated percentage of defoliation occurring after

the application of the various insecticides and mixtures was determined one week after the insecticides were applied. One week was the maximum time that toxic action was apparent in any of these tests. In all of the experiments, except number 2, the seed pods had already begun to set when the insecticides were applied, and unless the plants were badly defoliated by the caterpillars or injured by the insecticide, no reduction in yield was apparent.

DISCUSSION.—Cryolite, used at the rate of 10, 9 and 9 pounds per acre, respectively, in three different tests, gave excellent control of the caterpillars. Within one day after this insecticide was applied, many dead and sick larvae were observed and, within two days, satisfactory field control had been obtained. There was very little ragging of the foliage in any of these plots, and the beans produced a good crop of seed. A 50–50 mixture of cryolite and talc was applied to one plot in each of three experimental fields. This dust was applied at the rate of 12, 14 and 16 pounds per acre to the plots in the three respective tests. In all three cases good field control of caterpillars was obtained, and the soybeans produced a normal crop of seed. The rate of toxic action appeared to be slightly slower in these plots than in those on which straight cryolite was used.

A mixture composed of 1 part of cryolite and 2 parts of talc was used in two of the tests. The material was applied at the rate of 15 and 13 pounds per acre, respectively. In two more tests a mixture composed of 1 part of cryolite and 3 parts of talc was applied at the rate of 15 pounds per acre to each of the test plots. The most noticeable feature regarding these last two cryolite-talc mixtures was the slowness with which they killed the caterpillars. Very few dead larvae were noticed in these fields two days after dusting, although many of them appeared sick, but there was a noticeable let-up in the rate of defoliation in these plots as compared with the respective check plots. At the end of a week, it was estimated that approximately 70 per cent of the larvae had been killed in these tests. Although the foliage was noticeably ragged, the beans in these tests produced a normal or almost normal crop of seed.

Both calcium arsenate numbers 1 and 2 were applied to plots of soybeans in each of three different experiments. The rate of application of these materials varied from 6 to 13 pounds per acre. In all cases satisfactory control of the caterpillars was obtained. There was some injury to the soybean plants in all of the tests with these materials. The amount of injury appeared to be correlated with the rate of application, age of the beans and prevailing weather conditions following dusting.

The estimated percentage of a normal seed crop produced in these various plots dusted with calcium arsenate varied from 50 to 95. Although the beans in experiment number 2 were severely burned by both of these materials, they grew out of much of the original damage and produced about 70 per cent of a normal crop of seed.

The check plots in experiments 1 and 4 were completely denuded of foliage by the caterpillars and hence no seed was produced. The check plots in experiments 2 and 3 were about 50 per cent and 60 per cent defoliated, respectively. These beans put out new growth and later produced an almost normal seed crop.

Although moths were abundant in all of the test plots for six weeks to two months after the insecticides were applied, larvae did not again become sufficiently abundant to cause any further damage. It is believed that this was due to a combination of natural enemies. The egg parasite, *Trichogramma minutum* Riley, parasitized as high as 60 per cent of the eggs in some fields. Larval parasites and predators were very active, and late in the season a fungous disease destroyed a large number of caterpillars.

SUMMARY.—Four field experiments were conducted in the fall of 1937 to test methods to control the velvetbean caterpillar. Cryolite, mixtures of cryolite and talc, and two brands of safened calcium arsenate were the insecticides employed.

Cryolite, when applied at the rate of 9 to 10 pounds per acre, gave excellent control of the caterpillars. A mixture composed of 1 part of cryolite and 1 part of talc applied at the rate of 12, 14 and 16 pounds per acre on three respective test plots gave good field control of caterpillars.

Mixtures composed of 1 part of cryolite and 2 parts of talc, applied at the rate of 15 and 13 pounds per acre on two respec-

tive test plots, and 1 part of cryolite and 3 parts of talc, applied at the rate of 15 pounds per acre in two tests, gave fair field control of caterpillars.

Two brands of safened calcium arsenate, each applied to three test plots, varying in rate of application from 6 to 13 pounds per acre, gave good field control of caterpillars, but damaged the soybean plants. —9-14-38.

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Effects of Some Common Poisons in Sucrose Solutions on the Chemoreceptors of the Housefly, *Musca domestica* L.

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The purpose of these experiments was to determine the effects of various non-volatile poisons on the chemoreceptors of the housefly, *Musca domestica* L., as shown by the responses of the proboscis. In addition to the chemoreceptors on the mouth parts of the housefly, Deonier & Richardson (1935) found that chemoreceptors on its tarsal segments perform the function of taste. From the data presented in this paper, it is evident that these tarsal receptors enable the housefly to select discriminately the substances that will be touched by the proboscis.

Various authors have reported on the repellence of substances used in baits for houseflies. Elmore & Richardson (1936) measured the degree of repellence of a number of solutions containing formaldehyde, by calculating the weight of solutions in milligrams inbibed per gram of body weight by flies which were allowed to feed *ad libitum*. Pearson & Richardson (1933) determined the repellent effect of trisodium arsenite and arsenious acid in solution of various arsenic concentrations. These authors also reported the behavior of the fly when in contact with food. They observed that upon approaching a drop of liquid, the fly touched it first with the proboscis and soon afterwards with the anterior tarsi. Arsenious acid was not found to be repellent at concentrations of 0.330 gram As_2O_3 per 100 cubic centimeters of solution. Trisodium arsenite solutions of equal As_2O_3 content showed a definite repellent effect at concentrations greater than 0.148 gram per 100 cubic centimeters. In the experiments herein reported, repellence is studied by observing the effects of the compounds tested on the normal movements of the proboscis.

MATERIALS AND METHODS.—The larvae of the flies used in this study were reared in a mixture of bran and alfalfa meal at temperatures between 29 degrees and 32 degrees C. Flies reared by this method (Richardson 1932) gave homogenous responses to 1 molar sucrose solutions. These tests were made with unfed adult flies, which were approximately 20 hours old. The flies were manipulated for the tests by mounting them on cubes of beeswax, which were attached to wires according to the method used by Deonier & Richardson (1935). This is a modification of a method previously described by Minnich (1929).

The effects of chemically pure mercuric chloride, sodium fluoride, sodium fluosilicate, arsenic acid and arsenious acid on the chemoreceptors were tested. Arsenious oxide was dissolved in distilled water to produce the arsenious acid solutions. The arsenic content as As_2O_3 was determined by the standard iodine titration method. Stock solutions of known concentrations (g./100 cc.) were made up for the various compounds tested. Fresh test solutions were prepared daily by dissolving enough sucrose, in the form of granulated cane sugar, to make a 1 molar concentration in

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a solution containing the desired percentage of the substance to be tested. Of compounds that were only slightly soluble, a nearly saturated solution was tested first; and, if found repellent, dilutions were made to determine the threshold at which flies would respond. One molar sucrose solutions were used in the check tests. All the experiments were made at room temperature, between 25 and 30 degrees C.

Flies were taken at random and mounted. After recovery from the mounting procedure, they were divided at random into paired lots. The first lot was offered water until satiated; then tested on a 1 M sucrose solution as a check on the normal responses of the fly population under consideration. The second lot was offered water until satiated, and then tested on a 1 M sucrose solution which contained a known quantity of a given compound. The experimental animals were used only once, except in one experiment where subsequent tests on 1 M sucrose were made in studying the effects of 5 per cent mercuric chloride on the chemoreceptors.

When the chemoreceptors on the tarsi come in contact with a sucrose solution, positive proboscis responses are stimulated. The repellence of the various compounds was determined by a comparison of the responses initiated by the experimental solutions with the normal positive responses initiated by 1 M sucrose. The criterion of response to tarsal stimulations was the extension of the proboscis. Where the concentration of the added substance prevented a normal response to a sucrose solution, the substance was assumed to have a repellent effect on the chemoreceptors.

If a solution initiated responses of the proboscis, a further observation was possible on the effects of the substance being tested on the chemoreceptors located on the proboscis. A solution that stimulated a positive response, when in contact with the tarsal chemoreceptors, might produce a definitely negative response to the chemoreceptors on the proboscis and cause instant withdrawal of the proboscis. Whether a fly would or would not ingest a solution was also determined.

The effects of a substance on the chemoreceptors of the probsocis furnish a less definite criteria of response than do those of the tarsal chemoreceptors. Some individuals were only slightly repelled and touched the proboscis repeatedly to a given solution, while others held the proboscis in contact with the solution but were not observed to ingest. In both cases, a solution was considered positive to the chemoreceptors on the proboscis.

RESULTS.—Information concerning the effects of mercuric chloride, sodium fluoride, sodium fluosilicate, arsenious acid and arsenic acid on the normal responses of houseflies to sucrose is brought together in table 1. The check gives the variation of responses, of the fly populations studied, to 1 M sucrose; and is used in determining the significance of the repellent effects of the various poisons on the tarsal chemoreceptors. The chi-square test (Snedecor 1937) was used in determining if a difference brought about by the poisons really existed; or if the difference was due to variations in the fly populations. Since a test of the chemoreceptors on the proboscis depended on positive stimulations from the tarsus, flies which were negative to the first test were eliminated from further observation. The percentages of positively responding flies in the subsequent tests, on the chemoreceptors of the proboscis, were calculated from the number of flies positive to tarsal stimulations.

Data are presented for five concentrations of mercuric chloride. Concentrations of mercuric chloride above 1.25 per cent repelled the flies and prevented the sucrose from producing positive responses. At 0.5 per cent concentration, mercuric chloride in 1 M sucrose solution did not prevent stimulation of responses when the tarsal chemoreceptors were touched with the solution. The chemoreceptors on the proboscis initiated negative responses to this concentration, however, as shown by the withdrawal of the proboscis as soon as it touched the test solution. Concentrations of 0.1 per cent and 0.05 per cent were also repellent to the chemoreceptors on the proboscis. A 0.025 per cent concentration of mercuric chloride in sucrose gave slightly lower responses, when the tarsal chemoreceptors were stimulated, than did the check solutions of 1 M sucrose. The difference was not significant. The chemoreceptors of the proboscis gave negative reactions in 17.3 per cent of the flies responding to tarsal stimulations. A 0.01 per cent solution was not repellent to the

chemoreceptors of the proboscis. All flies which responded positively fed on this concentration. It is indicated from these data that concentrations of mercuric chloride greater than 0.01 per cent should not be used in a bait for houseflies that are 20 hours old.

A 3.5 per cent concentration of sodium fluoride in 1 M sucrose was not repellent. It did not prevent the stimulation of normal responses, and the flies readily fed on the solutions.

Sodium fluosilicate at 0.5 per cent concentration in 1 M sucrose caused a slightly lower response, when the tarsal chemoreceptors were stimulated; but the difference was not significant. Only one fly failed to feed out of the 50 which were found to be attracted to the test solution.

A solution of arsenious acid containing 1.84 grams of As_2O_3 per 100 cubic centimeters, used in making up a test solution, was not repellent when the tarsal chemoreceptors of the housefly were stimulated; but it was slightly repellent to the proboscis. Of the flies that were positive to stimulation of the chemoreceptors on the proboscis, 88.8 per cent fed on the poison solution.

Arsenic acid was repellent at concentrations above 0.25 per cent. The positive responses initiated by the chemoreceptors on the proboscis at 0.25 per cent concentration were significantly lower than the positive responses initiated by the tarsal chemoreceptors. Of the 92 flies which responded positively to tarsal stimulations, 14.1 per cent were definitely repelled when the chemoreceptors on the proboscis touched the test solutions. Of the flies that gave positive responses with the proboscis, 93.6 per cent fed upon these solutions. Some feeding occurred at higher concentrations of arsenic acid. The repellence of concentrations above 0.25 per cent to the housefly would preclude their use in poison baits, should the responses of the flies under natural conditions be found comparable to the responses of flies in these experiments.

Strong concentrations of some poisons were harmful to the chemoreceptors. For example, strong concentrations of mercuric chloride affected the tarsal chemoreceptors. Contact with a 5 per cent mercuric chloride solution resulted in temporary inhibition of the tarsal chemoreceptors, when 1 M sucrose solutions were offered. As a result, the responses of the proboscis were not stimulated. It is quite probable that in nature contact with such solutions would be avoided.

In a study of these harmful effects, 120 flies in groups of 10 were tested on a 1 M

Table 1.—Responses of the housefly, *Musca domestica* L., to 1 M sucrose solutions containing various poisons.

Sucrose Check		Compounds Tested	Concentration (g./100 cc.) in 1 Molar Sucrose Solution	Number of Flies Tested	Number of Flies Responding to Sucrose With Poison Added		Number of Flies Ingesting Poison Solution
Number Flies Tested	Number Flies Responding				Chemoreceptors on Tarsi Stimulated	Chemoreceptors on Proboscis Stimulated	
60	54	Mercuric chloride	0.500	60	49	0	0
40	38		0.100	40	36	0	0
40	39		0.050	40	34	0	0
50	49		0.025	50	46	38	13
40	40		0.010	40	35	34	34
57	49	Sodium fluoride	3.500	57	49	49	47
64	58	Sodium fluosilicate	0.500	64	53	50	49
90	74	Arsenious acid	1.840	90	82	72	64
100	80	Arsenic acid	1.000	100	37	8	7
100	87		0.500	100	58	35	26
100	90		0.250	100	92	79	74

sucrose solution. The tarsi were then immersed in a 5 per cent mercuric chloride solution, and a second sucrose test was made immediately. The sucrose tests were repeated 1, 3 and 5 hours after contact with mercuric chloride. At the beginning of the tests, 95.0 per cent of the flies gave positive responses to sucrose. Immediately following the immersing of the chemoreceptors in mercuric chloride, only one fly responded to sucrose. As shown by the responses to sucrose, the flies recovered as follows: 15.8 per cent after one hour had elapsed; 46.4 per cent after three hours; and 68.0 per cent after five hours.

SUMMARY.—In the adult housefly, the chemoreceptors of the proboscis were found to be more sensitive to certain compounds than were the chemoreceptors on the tarsi. Responses of the proboscis were initiated by tarsal stimulations with 1 M sucrose, which contained 0.5 per cent mercuric chloride. The chemoreceptors of the proboscis were definitely negative to a concentration of 0.05 per cent or above. The presence of mercuric chloride at a concentration of 0.025 per cent or greater affected the feeding of houseflies on 1 M sucrose.

Concentrations of the following compounds in 1 M sucrose solution were not repellent and did not materially inhibit feeding: sodium fluoride at 3.5 per cent, sodium fluosilicate at 0.5 per cent, and arsenious acid at a concentration of 1.84 grams As_2O_3 per 100 cubic centimeters of solution. Arsenic acid was repellent at concentrations above 0.25 per cent.

A 5.0 per cent concentration of mercuric chloride had a definite inhibitory effect on the chemoreceptors of the tarsi. This prevented the stimulation of proboscis responses in subsequent sucrose tests which followed immediately. Gradual recovery occurred in some of the flies after one to five hours, and normal responses of the proboscis were obtained with 1 M sucrose when the tarsi were st ulated.—9-6-38.

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Progress Report on the Investigations of Aliphatic Thiocyanates as Contact Insecticides

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During the last several years workers in various sections of the United States have investigated the use of aliphatic thiocyanates as insecticides. Murphy & Peet (1932, 1933) made two of the earliest reports relative to the value of these materials. They used aphids and mealybugs in their initial tests. Their results have been substantiated by such workers as Neiswander (1935), Richardson (1935) and Steiner (1935). In 1935, Murphy (1936) published the results that he obtained with an aliphatic thiocyanate when used upon *Tetranychus telarius* (L.), and *Paratetranychus pilosus* (G. & F.).

Since the spring of 1936, the authors have made careful and intensive tests of the aliphatic thiocyanate which is known

* Early publication of this paper has been secured by payment of the printing charge.

chemically as B. butoxy B[1] thiocyanodiethylether. The toxicity of this material to a number of pests of ornamentals and citrus was tested. The tests were made on plants in nurseries or in the field.

MATERIALS USED.—The experimental work involved the use of two forms of thiocyanate. One of these was a commercial concentrate containing 23 per cent of the thiocyanate together with an oil-soluble anhydrous emulsifier and pine oil. The other was a special concentrate, consisting of a combination of the thiocyanate and an oil-soluble anhydrous emulsifier and satisfactory petroleum oils. The oil used in this product had a viscosity of 65 seconds Saybolt, and an unsulphonatable residue of not less than 96 per cent.

The spreader used with the commercial concentrate was a 10 per cent solution of a complex mixture of sulphonated aromatic phenolic amines.

In the discussion of results the aforementioned materials will be called commercial concentrate, combination of thiocyanate and petroleum oil, and spreader.

METHODS.—All of the tests were made under field conditions, the authors being especially interested in the effect of the insecticide upon the host plants. Prior to the application of the spray, leaves of the test plants were secured and a careful microscopic count made of the living and dead insects present. From these data the percentage of living insects was calculated. The insecticide was then applied; a power sprayer usually being employed. The pressure was maintained at 200 to 250 pounds during the time of application. In some tests a barrel sprayer was used and the spray was applied at 75 to 125 pounds pressure. In other small tests a knapsack sprayer was used. Careful data were recorded relative to the climatic conditions, including the temperature and relative humidity.

Twenty-four to forty-eight hours after the insecticide was applied the authors selected leaves from the sprayed plants and made careful microscopic counts of the living and dead insects. In the case of armored scale insects, counts were made at the end of 48 hours, one week and four weeks. The data secured prior to the spray application and the above mentioned data were used in computing the percentage mortality which might be attributed to the aliphatic thiocyanate.

In the burning tests the spray was either applied with a power sprayer (citrus tests) or with a knapsack sprayer (ornamental tests).

CITRUS TESTS.—During the spring of 1936 the tests on citrus were begun; these were continued until the spring of 1937. The varieties used were Duncan grapefruit; Pineapple, Hamlin, Navel, Parson Brown, and Temple orange; Dancy tangerine and satsuma.

Some of the most abundant pests encountered in Florida citrus groves are *Dialeurodes citri* Ashm., *Aphis spiraecola* Patch., *Pseudococcus citri* (Risso), *Frankliniella tritici bispinosus* Morgan., *Eriophyes oleivorus* Ashm., *Tetranychus sexmaculatus* Riley, *Paratetranychus citri* McG., *Chrysomphalus aonidium* (L.), and *Lepidosaphes beckii* (Newm.). Although all of the aforementioned insects were used in the tests, the majority of the data were accumulated on the toxicity of the sprays to *Dialeurodes citri* and *Aphis spiraecola*.

CITRUS TESTS ON THE CITRUS WHITEFLY.—In the tests on citrus whitefly, *Dialeurodes citri*, both the commercial concentrate and a combination of the thiocyanate with petroleum oils were used. A spreader was employed with the former. These two types of sprays were applied under temperature conditions ranging from 77 to 95 degrees F.

In the combination of the thiocyanate with petroleum oils of $\frac{3}{4}$ of 1 per cent up to 2 per cent, the average per cent kills for applications were as follows: $\frac{3}{4}$ of 1 per cent, 80.0; 1 per cent, 87.5; $1\frac{1}{2}$ per cent, 94.5; and 2 per cent, 95.1. The first two tests were applied at a temperature of 87 degrees F., while the last two were made at a temperature of 95 degrees F. These data indicate that a $1\frac{1}{2}$ per cent concentration of this spray is very satisfactory for citrus whitefly control. This dilution contains 0.0713 per cent thiocyanate plus 0.0937 per cent oil.

Various concentrations of commercial concentrate plus spreader were used. These varied from 1–800 up to 1–3200. In the majority of tests the spreader was added at the rate of 1–200 up to 1–800. The most important factor discovered in the application of these sprays was the desirability of making the application during the peak of whitefly adult activity.

The thiocyanate is an effective contact spray for the adults and if applied under proper pressure it will in general produce a 100 per cent mortality of the mature stages. Likewise, it has a strong ovicidal effect and is extremely toxic to the crawler stage of this species. The materials were applied at the rate of 1–800 of the thiocyanate plus spreader at the rate of 1–200 up to a dilution of 1–3200 plus 1–200 spreader. The larval mortality ranged from a low of 37.9, which was the average per cent at a concentration of 1–2400 plus spreader at 1–600, to a high of 88.5 per cent at a dilution of 1–1600 plus spreader at the rate of 1–200. Adult mortality ranged from 95 to 100 per cent. Dilutions of 1–1000 up to 1–1600 produced a 100 per cent mortality, and dilutions of 1–2400 plus 1–200 of the spreader produced a mortality of 95 per cent. The most effective spray to use should be based upon the lethal effect upon all stages. The data obtained indicates that the most effective spray is one that contains the aliphatic thiocyanate in the ratio of 1–1600 with the spreader at 1–400.

CITRUS TESTS ON THE GREEN CITRUS APHID.—A total of 54 tests was conducted on the green citrus aphid, *Aphis spiraecola*. In each test a total of 4–10 infested trees was used. In all tests the commercial concentrate plus a spreader was used. It was applied at dilutions ranging from 1–720 thiocyanate plus spreader, at dilution of 1–180, up to a dilution of 1–3200 with spreader added at 1–800. The former dilution produced a mortality of 98.3 per cent. The spray was applied at a temperature of 82 degrees F. At the dilution of 1–3200 the mortality was 46.0 per cent. This spray application was made when the temperature was 91 degrees F. The tests conducted with a spray having a thiocyanate dilution of 1–1200 with spreader in the proportion of 1–300 produced an aphid mortality of 96.6 per cent. At a dilution of 1–2400 plus spreader at 1–200 the thiocyanate produced an aphid mortality of 91.5 per cent. These tests were made at temperatures of 86 and 85 degrees F., respectively. The data obtained indicates that this thiocyanate is an effective and economical aphicide at dilutions of 1–1200 to 1–2400. The most effective dilution is 1–1200 to 1–1400. An interesting fact that was observed in aphid control was that aphids killed by this material were eagerly removed and devoured by ants. It was also proved that the material acted only as a contact spray, and the necessity of careful application and proper spreading was demonstrated.

CITRUS TESTS ON *Pseudococcus citri*, *Chrysomphalus aonidum* AND *Eriophyes oleivorus*.—Numerous tests were made on the citrus mealybug, *Pseudococcus citri*. In general the infestations treated were old ones in which the pest had become so abundant that they had become layered; that is, with several thicknesses of mealybugs. As the thiocyanate is only a contact poison this condition presented some experimental difficulties. Mealybugs are exceedingly hard to wet but it was found that the aliphatic thiocyanate plus spreader completely coated the upper layer of insects. When the spray was applied at a concentration of 1–800 plus spreader at 1–200 the total kill was 57 per cent. The mortality of the upper layer was 98.5 per cent. The check plots in which a 2 per cent oil emulsion was used showed a total mortality of only 2 per cent. These tests indicate very emphatically the efficacy of this material as a destroyer of mealybugs; also the necessity of early application in order to obtain the benefits before the infestation has advanced to the uncontrollable "layered" stage. In Florida it has also been demonstrated that aliphatic thiocyanates are effective in the control of mealybugs on sugar cane and ornamentals.

The armored scales, especially Florida red scale, *Chrysomphalus aonidium*, are exceedingly resistant to modern insecticides. Concentrated oil emulsions at the rate of 2 per cent by volume of oil are efficient scalecides. However, these sprays have several objections. Aliphatic thiocyanates alone do not seem to be effective when used against the mature scales. They are valuable in the control of the crawler stage and first stage nymph. They also seem to hold some promise in combination with oils, thereby encouraging a reduction in the quantity of oil used.

In a great part of the Florida citrus belt the grower considers the rust mite, *Eriophyes oleivorus*, the major pest of his crop. It is certainly true that the production of "bright" fruit is in great part determined by the successful control of this pest. At present lime sulfur plus wettable

Table 1.—Toxicity of aliphatic thiocyanates to several ornamental plants.

TEST	HOST	CONCENTRATION OF SPRAY	CONCENTRATION OF SPREADER	TEMPERATURE IN DEGREES F.	RELATIVE HUMIDITY	INJURY
1	Cherry laurel	1½% thiocyanate oil combination*	None used	93	72	Slight; light marginal burn
2	Cherry laurel	2½% thiocyanate oil combination	None used	93	72	Tip and marginal burning—50% damage
3	Cherry laurel	3% thiocyanate oil combination	None used	93	72	Complete destruction; leaves dropped in one week
4	*Ligustrum*	1½% thiocyanate oil combination	None used	93	72	None
5	*Ligustrum*	2½% thiocyanate oil combination	None used	93	72	None
6	*Ligustrum*	3% thiocyanate oil combination	None used	93	72	Slight marginal burning
7	*Ligustrum*	1–400	1–400	90	66	Marginal burning from tip to petiole
8	*Ligustrum*	1–600	1–150	90	66	Marginal burning from tip to petiole; not so severe as 1–100
9	*Ligustrum*	1–800	1–200	90	66	Slight marginal burn near petiole
10	*Ligustrum*	1–100	1–250	90	66	None
11	Croton	1–400	1–100	80	86	None
12	Croton	1–400	1–100	82	90	None
13	Croton	1–600	1–150	82	90	None
14	Croton	1–800	1–200	82	90	None
15	Chrysanthemum	1–1000	1–250	100	57	Leaves scorched
16	Chrysanthemum	1–1200	1–300	100	57	Heavy tip and marginal burn
17	Chrysanthemum	1–1400	1–350	100	57	Moderate tip and marginal burn
18	Chrysanthemum	1–1800	1–450	100	57	None
19	Chyrsanthemum	1–1000†	1–250	100	57	None
20	Viburnum	1–400	1–100	89	68	None
21	Viburnum	1–600	1–150	89	68	None
22	Viburnum	1–800	1–200	89	68	None
23	*Pittosporum*	1–400	1–100	82	90	None
24	*Pittosporum*	1–600	1–150	82	90	None
25	*Pittosporum*	1–800	1–200	82	90	None

Table 1 (Continued)

TEST	HOST	CONCENTRATION OF SPRAY	CONCENTRATION OF SPREADER	TEMPERATURE IN DEGREES F.	RELATIVE HUMIDITY	INJURY
26	Feijoa	1–400	1–100	82	90	Complete destruction of leaves
27	Feijoa	1–600	1–150	82	90	Complete destruction of leaves
28	Feijoa	1–800	1–200	82	90	Slight tip and marginal injury
29	Feijoa	1–1000	1–250	82	90	None

* 1½ per cent dilution of this combination contains 0.0713 per cent thiocyanate plus 0.0937 per cent oil.
† Rinsed off after 15 minutes.

or colloidal sulfur are the most generally used spray materials for these pests. Data obtained by the authors show that aliphatic thiocyanate at a dilution of 1–2000 plus spreader is toxic to these mites. This spray material is compatible with lime sulfur and therefore holds some promise as a combination spray.

CITRUS BURNING TESTS.—All tests with this aliphatic thiocyanate indicate that there is no immediate or cumulative injury from applications. Burning tests were made on all varieties of citrus listed at the beginning of this discussion. They were made under spring and summer conditions, with high and moderate temperatures, and high and low humidity. Concentrations of 1–720 plus spreader at 1–180 were applied weekly over a period of five months with absolutely no indication of accumulative injury to old or new foliage, or to the fruit.

ORNAMENTAL TESTS.—In April, 1937, the tests on ornamental plants were begun. They were continued until May, 1938. The plants used were *Ligustrum*, *Pittosporum*, camphor, cherry laurel, feijoa, oleander, croton, chrysanthemum, viburnum and California privet.

Many of the pests that attack citrus in Florida likewise attack a wide range of the beautiful ornamental plants that are used for decorative purposes. Ornamentals that are in close proximity to citrus plants must be constantly treated or permitted to serve as a breeding ground for citrus pests.

In our tests *Dialeurodes citri*, *Chrysomphalus aonidum*, *Pseudococcus citri* and several species of ornamental aphids were used.

ORNAMENTAL TESTS ON CITRUS WHITEFLY.—Citrus whitefly infestations on *Ligustrum* and California privet were treated with a 1 per cent concentration of the combination thiocyanate and petroleum oil spray, which produced a mortality ranging from 69.2 to 98.8 per cent. This concentration contains 0.0475 per cent thiocyanate plus 0.625 per cent oil. The applications were made at temperatures of 83 to 91 degrees F. A total of seven tests was made, 10 plants being used in each test. No injury was produced.

ORNAMENTAL TESTS ON ORNAMENTAL APHIDS.—All of the ornamental plants listed above were used in these tests. The combination thiocyanate plus oil was used at a 1 per cent concentration and under temperatures ranging from 80 to 95 degrees F. The per cent mortality ranged from 98 to 100 with an average of 99.3 per cent.

Aliphatic thiocyanate plus spreader was also used in many tests. Concentrations ranging from 1–1000 plus spreader at 1–250 up to 1–1400 plus spreader at 1–350 were applied. At the more concentrated dilution the average per cent kill was 99.4. At the dilution of 1–1400 the per cent kill averaged 99.2. The latter would serve as an efficient aphicide for ornamentals.

ORNAMENTAL TESTS ON *Pseudococcus citri*.—The citrus mealybug tests were made on croton and chrysanthemum. The aliphatic thiocyanate was applied at a concentration of 1–1000, 1–1400 and 1–1800. Spreader was added at 1–250, 1–350 and 1–450, respectively. At a concentration of 1–1000 the mortality average was 98.2 per cent. At a concentration

of 1-1200 the mortality averaged 81.5 per cent. At a concentration of 1-1800 the average per cent kill was only 46.

ORNAMENTAL TESTS ON *Chrysomphalus aonidum*.—The control tests conducted on ornamentals for this species confirmed the data presented under citrus tests.

ORNAMENTAL BURNING TESTS.—Table 1 illustrates the toxicity of aliphatic thiocyanates to several ornamental plants.

The tests recorded in table 1 were conducted during the summer months and show clearly the permissible strengths for use on the varieties represented. If greater concentrations are necessary for successful control of resistant species of insects the aliphatic thiocyanate concentration may be increased provided the material is syringed off 30 minutes to 1½ hours after application.

Aliphatic thiocyanate investigations are to be continued on several points of interest, and at an appropriate time the data will be released.—9-24-38.

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Locations for Blowfly Traps: Abundance and Activity of Blowflies and Other Flies in Menard County, Tex.

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This paper reports the results of a four-year test to determine the comparative abundance and activity of blowflies, especially species of *Cochliomyia*‡ and *Phormia*, as indicated by the numbers of each species taken in flytraps placed in different locations and surroundings at Menard, Tex., from April 1, to March 31, 1933.

THE TEST AREA.—The area in which the test was conducted comprised approximately 250 sections of typical ranch land situated in the northwestern corner of Menard County, Tex. This area lies within that section of the plains known as the Edwards Plateau. The elevation is from 2,000 to 2,200 feet. The topography ranges from gently rolling and hilly to moderately rough and broken. Shallow, dry, rocky draws separate the hills. According to weather records kept by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture at the Menard field laboratory, the mean annual rainfall averaged 26.9 inches for the four years of the test and the average daily maximum temperature was 80.7 degrees F. for the the same period. The vegetation of the area consists mostly of scattered live oak, chin oak, mesquite and various small thorny shrubs. Weeds and grass grow luxuriantly during seasons

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† Early publication of this paper has been secured by payment of the printing charge.

‡ Since the studies reported herein were completed it has been found that two species have been included heretofore under the name *Cochliomyia macellaria* F. (Cushing & Patton 1933). Field observations have established the fact that while *C. americana* appears to be the primary aggressor in cases of myiasis, it is followed by *C. macellaria*, although the amount of damage caused by the latter species has not been definitely determined. *C. macellaria* is much more abundant than *C. americana*, and both species are taken in traps. The proportion of the two species taken in traps is about 1 *C. americana* to 3,000 *C. macellaria*.

of sufficient rainfall. Although in general this section is not too rugged for cultivation, the rocky, shallow soil makes farming impracticable, except in occasional small areas and along the valley of the San Saba River.

Aside from slight local or sectional environmental variations, the area in which the test was conducted is similar to the vast livestock districts of western and southwestern Texas. Ranch practices vary but slightly throughout these districts.

tion of the weather conditions likely to be encountered in this section. The period from April 1 of one year to March 31 of the following year was considered as one season. The seasons of 1929–30 and 1931–32 were considered as average seasons with respect to range conditions, rainfall and other factors. From April 1, 1930, to March 31, 1931, the rainfall was only slightly below the average for the four-year period but occurred too late in the season to produce sufficient feed. The

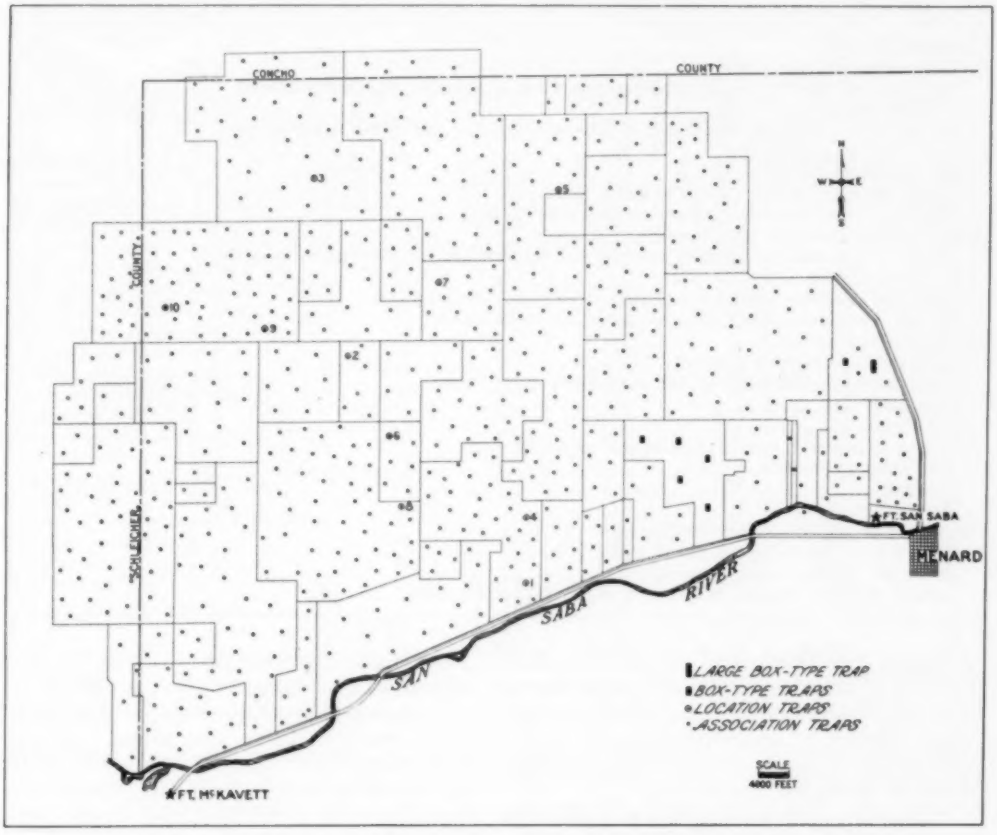

FIG. 1.—Map of part of Menard County, Tex., showing the locations where blowfly traps were operated from April 1, 1929, to March 31, 1933.

For these reasons there is little doubt that results of the work reported herein will be applicable to most of the regions in Texas where screwworm and woolmaggot infestations cause serious losses to the livestock industry.

WEATHER CONDITIONS DURING TEST.—The four years during which the experiment was conducted (from April 1, 1929, to March 31, 1933) gave a fair representa-

spring and summer months were extremely dry and consequently livestock suffered from want of food. It became necessary to remove large numbers of cattle in order to protect sheep and goats from starvation. The season of 1932–33 was better than normal; rainfall occurred at the right time, ranges were in excellent condition and livestock wintered well and were in good flesh for marketing in the

spring. However, during this season the loss occasioned by screwworm infestations was higher than in the other years of the test.

TYPE-LOCATIONS.—The locations of traps were studied with reference to the density of shade; protection from direct wind; distance and direction from water; elevation; distance from corrals, residences, barns, etc., where these were grouped together; and kind, size and density of surrounding timber and brush. Ten type-locations were selected, covering a circuit of approximately 80 miles, within an area where 652 range flytraps were in operation, fig. 1.

Table 1 gives a comparative description of the type-locations with reference to the more important factors considered.

TYPE OF TRAP.—The type of flytrap used in each location was the Government all-metal cone type, described in United States Department of Agriculture Farmers' Bulletin 734. Bait pans for these traps were of galvanized tin, 14 inches in diameter and 4 inches deep. During the last two seasons of the test, enameled bait pans of the same dimensions were substituted, as enameled pans are more easily cleaned, and they last longer than galvanized ones.

BAIT.—Two pounds of lean beef, in most cases taken from the same animal, and 1½ gallons of water were used for bait. Nicotine sulphate at the rate of 4 cubic centimeters per gallon of water was added to prevent larvae from breeding in the bait. At each emptying bait traps were rebaited with fresh meat and water.

EVAPORATION.—A white, spherical, porous-cup Livingston atmometer was placed at each trap location for the study of evaporation; commercial distilled water was used in their operation. The atmometers were cleaned with a soft brush at regular intervals throughout the season. Atmometers were operated from April 21 to October 21 of each season, being removed during the remainder of the season to avoid freezing. The amount of evaporation was recorded at each emptying date. At the end of each season the cups were sent to Dr. Burton E. Livingston, Riderwood, Md., to be restandardized. The restandardized coefficient and the coefficient of each cup at the beginning of each season were used in computing the corrected evaporation. The amount of water evaporation was indicative of weather conditions in the vicinity of each trap.

Table 1.—Locations of blowfly traps with reference to certain environmental factors.

FACTORS STUDIED	LOCATION NO.
Amount of shade:	
None—trap in open sunlight	10
Medium—no direct sunlight; broken shade made by branches and leaves at least 4 feet above top of trap	1, 2, 3, 4, 5, 6, 7, 8
Dense—shade made by dense mat of live-oak branches and leaves 4 feet above top of trap; no sunlight	9
Protection from direct wind:	
None—no surrounding timber to break wind	7
Moderate—surrounding timber provided windbreak	1, 2, 3, 4, 5, 6, 8, 9, 10
Density of surrounding timber and underbrush:	
Dense—large, heavy timber of live oak and Spanish oak; underbrush of small, thorny shrubs	6
Medium—medium-sized live-oak trees, chin-oak underbrush	1, 2, 3, 4, 5, 8, 9, 10
Sparse—mesquite trees widely scattered, no underbrush	7
Distance from water:	
Near pond or running stream	1
One hundred yards south of dirt or concrete water tank	2, 3, 9, 10
One mile	4, 5, 6, 7
Two miles	8
Distance from barns, corrals, houses and feed lots:	8
One hundred yards	2
One mile	1, 3, 4, 5, 6, 7, 9, 10
Two miles	
Elevation in relation to surrounding area:	
Higher—on top of highest hill in vicinity	8
Average—similar to surrounding area	2, 7, 9, 10
Lower—bank of stream, between or at the foot of low hills	1, 3, 4, 5, 6

EMPTYING PERIODS.—From April 1 to October 21 of each season the traps were emptied of flies at 10-day intervals; from October 22 to January 11, 20 days constituted the trapping period; and during the winter and early spring, January 12 to March 31, traps were emptied at 40-day intervals. There were 26 emptying periods each season.

VOLUME AND WEIGHT OF FLIES.—At each emptying date all live flies were killed and the contents of each trap were placed in separate paper bags. The amount of flies captured by each trap was determined by weight. During the last season of the test, the amount of flies taken was also determined by volume, a special measuring apparatus graduated to tenths of a quart being used for the purpose.

SAMPLES.—From the catch of each trap a random sample of 500 flies was taken at each emptying date. These flies were identified as to genus in the case of *Cochliomyia* and *Phormia* and as to species in practically all other genera, and they furnished an adequate representation of the species of flies captured at each location. When the total catch of a trap was not sufficient to furnish a sample of 500 flies, all the flies caught were identified and used as the sample, The following tables show the number, the species, and the percentage of each species of all flies taken in these samples, and the total amount of flies caught at each location.

DISCUSSION.—In analyzing the results of this study, we find that table 2 shows the comparative abundance of each species for each year of the test. It is noted that there is a progressive increase in the number of *Cochliomyia* spp. from year to year. The abundance of *Phormia* spp. is probably more closely correlated with seasonal weather conditions, which no doubt accounts for the fluctuation in the number of flies of this species from year to year. The number in all species of *Sarcophaga* show a decrease during the four years. No marked progressive change is apparent in the numbers of other species.

Table 3 shows the number of flies of each species in the total samples taken from each location for the four-year period. It will be seen that proportionally the greatest number of *Cochliomyia* spp.

Table 2.—Number and species of flies in samples from all locations.

SPECIES	NUMBER OF FLIES IN SAMPLES FROM ALL TRAPS					
	1929–30 Season	1930–31 Season	1931–32 Season	1932–33 Season	Total for Four Seasons	Seasonal Average
Cochliomyia spp.	45,322	54,247	56,323	65,440	221,332	55,333
Phormia Spp.	28,787	22,022	38,862	36,003	125,674	31,319
Sarcophagidae	24,852	23,023	14,704	8,060	60,639	17,660
Cynomyia cadaverina Desv.	2,722	1,760	2,140	1,081	7,703	1,926
Calliphora coloradensis Hough	4,903	4,132	1,431	1,438	11,904	2,967
Calliphora erythrocephala Meig.	24	1	3	0	28	7
Calliphora latifrons Hough	102	353	43	7	505	126
Calliphora viridescens Desv.	430	37	64	43	574	144
Lucilia cuprina Wied.	10	3	2	4	19	5
Lucilia sericata Meig.	20	10	9	0	39	10
Lucilia unicolor Towns.	7,498	5,475	5,871	9,926	28 770	7,193
Cryptolucilia caesarion Meig.	246	280	15	71	612	153
Musca domestica L.	310	316	247	393	3,266	317
Synthesiomyia nudiseta V. d. W.	925	840	397	608	2,770	693
Stomoxys calcitrans (L.)	2	0	0	9	11	3
Muscina stabulans Fall.	13	23	4	26	66	17
Muscina assimilis Fall.	0	4	84	63	151	38
Neomuscina tripunctata V. d. W.	64	30	1	218	313	78
Hydrotaea dentipes F.	138	183	88	59	468	117
Ophyra aenescens Wied.	42	53	2	33	130	33
Ophyra leucostoma Wied.	0	22	113	38	173	43
Chrysomyza demandata F.	6	14	22	9	51	13
Tachinidae	1,032	951	1,021	135	3,139	785
Miscellaneous	2,874	4,250	3,995	3,118	14,237	3,559
Grand total	120,322	118,029	125,441	126,782	490,574	122,648

Table 3.—Number and species of flies in samples taken at each location during four seasons, 1929–1933.

Species of Flies	Number of Flies in Samples From Type-Location No.										
	1	2	3	4	5	6	7	8	9	10	All Locations
Anthomyiidae:*											
Coenosia spp.	35	9	22	39	19	24	6	44	23	6	227
Dendrophaonia texensis Mall.	0	6	24	5	9	7	1	16	1	2	71
Eulimnophora arcuata Stein	200	330	599	225	297	254	141	491	487	134	3,158
Fannia canicularis L.	30	52	93	59	67	53	45	105	75	25	604
Fannia femoralis Stein	163	151	131	182	161	173	103	258	161	98	1,581
Fannia spp.†	9	8	6	13	14	11	12	20	26	5	124
Helina lucorum Fall.	6	11	12	16	36	16	7	28	13	5	150
Hydrotaea dentipes F.	192	24	23	62	50	36	15	32	21	13	468
Hylemyia cilicrura Rond.	3	53	32	36	43	23	24	105	13	9	341
Hylemyia cinerilla Fall.	1	25	17	11	6	5	14	12	12	3	106
Hylemyia spp.†	52	141	147	90	82	75	149	80	59	46	921
Myiospila meditabunda Loew	13	15	13	16	9	17	7	9	6	7	112
Ophyra aenescens Wied.	29	7	6	10	23	16	10	14	8	7	130
Ophyra leucostoma Wied.	66	6	5	10	15	16	4	9	5	37	173
Pegomyia affinis Stein	50	145	430	456	256	400	97	1,865	670	358	4,727
Pegomyia spp.†	14	13	30	19	13	8	3	41	12	6	159
Spilogona spp.	19	27	62	35	46	92	42	125	36	42	526
Asilidae:											
Atomosia puella Wied.	1	2	1	0	0	0	1	0	3	0	8
Cordyluridae:											
Scatophaga stercoraria L.	3	6	7	1	1	3	3	3	1	1	29
Dexiidae spp.	0	0	0	1	1	0	1	6	2	0	11
Drosophilidae:											
Rhinoleucophenga obesa Loew.	0	0	1	0	4	30	1	2	0	1	39
Lauxaniidae:											
Lauxania cucephala Loew.	1	0	5	7	3	9	8	1	3	1	38
Muscidae:											
Cryptolucilia caesarion Meig.	29	72	57	46	94	29	35	150	65	35	612
Graphomyia maculata Scop.	5	1	1	0	1	0	0	0	0	1	9
Musca domestica L.	71	480	161	38	56	38	103	114	63	142	1,266
Muscina stabulans Fall.	4	5	3	14	4	12	3	9	9	3	66
Muscina assimilis Fall.	9	10	13	20	9	36	4	25	23	2	151
Neomuscina tripunctata V.d.W.	17	13	21	93	43	46	13	29	24	14	313
Stomoxys calcitrans (L.)	2	0	3	0	1	0	1	1	1	2	11
Synthesiomyia nudiseta V.d.W.	252	231	256	352	425	290	162	340	266	196	2,770

Table 3 (Continued)

SPECIES OF FLIES	NUMBER OF FLIES IN SAMPLES FROM TYPE-LOCATION NO.										
	1	2	3	4	5	6	7	8	9	10	All Locations
Calliphoridae:											
Calliphora coloradensis Hough	786	1,088	1,179	1,452	1,286	1,480	1,484	910	964	1,275	11,904
Calliphora erythrocephala Meig	6	1	2	2	3	2	4	4	3	1	28
Calliphora latifrons Hough	37	36	33	88	56	79	39	13	46	78	505
Calliphora viridescens Desv	72	53	57	74	54	58	43	37	61	65	574
Cochliomyia spp	24,505	27,145	20,659	19,143	20,326	21,421	22,653	20,407	16,512	28,561	221,332
Cynomya cadaverina Desv	978	659	724	874	1,014	878	926	491	684	475	7,703
Lucilia cuprina Wied	2	4	0	4	3	1	1	1	0	3	19
Lucilia sericata Meig	5	9	1	0	5	5	5	3	1	6	39
Lucilia unicolor Towns	5,165	762	1,779	4,063	5,148	5,271	535	2,937	1,813	1,297	28,770
Phormia spp	14,028	12,235	12,464	12,955	12,436	13,065	11,305	11,207	13,584	12,395	125,674
Ortalididae:											
Chrysomyza demandata F	2	12	6	5	5	4	6	1	7	3	51
Euxesta nitidiventris Loew	22	20	11	21	13	7	13	15	24	13	159
Euxesta notata Wied	13	19	30	40	7	15	35	11	20	7	197
Stenopterina brevipes F	27	15	26	113	25	13	33	57	23	14	346
Pipunculidae:											
Pipunculus nigripes Loew	0	0	0	1	1	3	0	1	2	0	8
Sarcophagidae:‡											
Amobia floridensis Towns	0	0	0	0	1	0	0	1	0	1	3
Hilarella hilarella Zett	0	0	0	0	1	0	0	0	0	0	1
Macronichia sp	0	0	0	0	0	0	0	1	0	0	1
Sarcophaga aculeata Ald	0	1	7	3	2	0	0	9	0	1	23
Sarcophaga adamsi Hall	68	33	54	54	46	52	12	112	46	35	512
Sarcophaga alcedo Ald	40	8	16	30	42	26	1	58	5	5	231
Sarcophaga barbata Thom	0	0	10	7	5	7	2	30	3	6	70
Sarcophaga bisetosa Park	0	0	0	0	0	0	0	1	0	0	1
Sarcophaga bishoppi Ald	5	49	37	15	13	18	121	34	22	18	332
Sarcophaga bullata Park	9	1	12	15	12	11	6	8	4	14	92
Sarcophaga caridei Breth	0	0	0	0	0	1	0	2	1	0	4
Sarcophaga cimbicis Towns	0	0	0	0	4	0	0	0	0	0	4
Sarcophaga coloradensis Ald	0	0	0	1	0	1	0	1	0	0	3
Sarcophaga davidsoni Coq	0	0	0	3	0	0	0	1	0	0	4
Sarcophaga cleodis Ald	0	5	5	1	1	1	0	8	0	4	25
Sarcophaga errabunda V.d.W	54	198	303	92	199	232	236	205	111	305	1,935
Sarcophaga flavipalpis Ald	43	30	81	76	91	60	33	78	18	40	550
Sarcophaga haemorrhoidalis Fall	1	0	0	0	0	0	0	0	0	0	1
Sarcophaga hunteri Hough	0	0	0	0	1	0	0	0	0	0	1
Sarcophaga impar Ald	5	5	9	14	4	11	7	4	7	8	74

Table 3 (Continued)

SPECIES OF FLIES	NUMBER OF FLIES IN SAMPLES FROM TYPE-LOCATION NO.										
	1	2	3	4	5	6	7	8	9	10	All Locations
Sarcophaga kellyi Ald.	25	164	194	160	214	178	410	290	186	91	1,912
Sarcophaga laakei Hall.	6	8	52	3	25	7	12	8	40	20	181
Sarcophaga latisetosa Park.	20	14	32	13	16	16	6	27	19	23	186
Sarcophaga lherminieri R-D.	11	39	137	24	70	49	73	63	64	48	578
Sarcophaga marginata Ald.	0	0	0	0	0	1	0	0	0	0	1
Sarcophaga masculina Ald.	2	6	12	14	19	13	2	26	12	3	109
Sarcophaga omani Hall.	0	3	0	0	0	0	0	1	0	0	4
Sarcophaga pectinata Ald.	3	8	2	2	4	0	7	3	1	1	31
Sarcophaga plinthopyga Wied.	37	247	231	102	147	198	303	258	161	288	1,972
Sarcophaga prohibita Ald.	34	94	174	89	307	201	181	245	151	192	1,668
Sarcophaga rapax Wlk.	22	12	31	45	44	84	9	123	10	6	386
Sarcophaga rudis Ald.	0	0	0	0	0	0	0	1	1	0	2
Sarcophaga sarracenioides Ald.	166	58	214	137	228	202	50	137	98	107	1,397
Sarcophaga sclesta Hall.	9	16	3	15	12	11	1	67	9	3	144
Sarcophaga semimarginalis Hall.	1	1	0	0	0	1	1	0	0	1	5
Sarcophaga stimulans Walk.	73	171	521	182	327	214	231	338	162	157	2,376
Sarcophaga sueta V.d.W.	134	369	334	112	210	200	149	268	194	398	2,368
Sarcophaga sulculata Ald.	46	398	840	196	314	208	996	268	247	330	3,843
Sarcophaga tenuiventris V.d.W.	44	14	28	29	65	46	9	79	25	12	351
Sarcophaga utilis Ald.	1	4	0	1	1	0	2	0	0	2	11
Sarcophaga xanthosoma Ald.	0	0	0	0	0	0	0	1	0	0	1
Senotania rufiventris Coq.	0	0	2	2	0	1	3	0	0	0	8
Senotania spp.†	0	0	0	1	2	0	0	0	0	0	3
Sphenometopa tergata Coq.	0	0	0	0	0	1	0	0	0	0	1
Sphenometopa spp.†	0	0	0	0	1	0	0	0	0	0	1
Tribe miltogrammini	0	3	3	5	8	2	2	10	0	3	36
Syrphidae:											
Allograpta obliqua O. S.	4	4	6	106	4	4	6	9	5	2	150
Baccha clavata F.	0	0	0	1	5	1	0	0	1	0	8
Chrysotoxum ypsilon Will.	0	0	0	0	1	1	0	0	0	0	2
Eupeodes volucris O. S.	6	41	39	26	26	18	55	24	34	10	279
Mesogramma marginata Say	0	0	0	0	0	0	0	2	0	0	2
Syrphus americanus Wied.	0	0	4	0	2	1	0	1	1	0	9
Volucella sp.	0	0	0	1	0	1	0	0	0	0	2
Tachinidae:§											
Achaetoneura archippivora Will.	0	0	3	0	1	0	0	0	0	0	4
Achaetoneura spp.†	0	1	0	4	6	2	0	7	1	2	23
Acroglossa hesperidarum Will.	0	0	1	0	3	0	0	1	0	0	5

Table 3 (Continued)

Table 3 (Continued)

SPECIES OF FLIES	NUMBER OF FLIES IN SAMPLES FROM TYPE-LOCATION NO.										
	1	2	3	4	5	6	7	8	9	10	All Locations
Acroglossa sp.†	0	0	0	0	1	0	0	0	0	0	1
Archytas apicifera Walk.	17	19	88	46	24	21	13	22	100	7	357
Archytas aterrima Desv.	0	0	0	2	1	0	0	0	0	0	3
Archytas lateralis Macq.	0	0	0	2	0	0	0	0	0	0	2
Archytas metallica Desv.	0	0	0	0	1	2	0	0	0	0	3
Archytas piliventris V.d.W.	0	4	0	0	4	0	5	3	0	0	16
Archytas spp.†	7	0	1	0	1	0	0	1	2	0	12
Belvosia bifasciata F.	0	1	0	0	2	3	0	1	5	1	13
Belvosia semiflava Ald.	0	0	0	0	0	0	0	1	0	0	1
Belpharipeza adusta Loew	0	0	0	0	1	0	0	0	0	0	1
Belpharipeza spp.†	1	2	1	4	5	3	0	6	3	0	25
Catalinovoria cauta Towns.	0	0	0	0	0	0	1	0	0	0	1
Catemophyrs sequens Towns.	5	0	8	20	14	2	0	53	10	7	119
Chaetogaedia crebra V.d.W.	0	0	0	1	0	1	0	1	0	0	3
Chaetogaedia monticola Bigot	8	15	16	30	246	52	2	86	6	12	473
Chaetogaedia spp.†	0	0	0	5	9	1	0	2	0	1	18
Cnephalia hebes pansa Snow	0	1	0	0	0	1	2	0	1	2	7
Copecrypta nitens Wied.	0	0	0	0	0	0	0	0	1	1	2
Cuphocera hirsuta Towns.	2	0	0	0	2	0	0	0	0	0	4
Cuphocera sp.†	0	0	0	0	0	0	0	0	1	0	1
Distichona varia. V.d.W.	0	0	0	0	0	0	2	1	0	0	3
Doryphorophaga doryphorae Riley	0	2	0	1	0	0	1	2	0	0	6
Eucelatoria armigera Coq.	0	30	0	0	0	0	1	0	1	0	31
Exorista larvarum L.	0	0	0	2	2	1	0	2	0	0	7
Exoristoides sp.	0	0	0	0	1	0	0	0	0	0	1
Gaediopsis sierricola Towns.	0	1	0	1	0	0	0	0	0	0	2
Gaediopsis setosa Coq.	0	0	0	0	0	0	0	2	0	0	2
Gaediopsis spp.†	0	0	0	1	9	3	0	2	4	0	19
Gonia sequax Will.	0	0	0	0	0	0	0	2	0	0	2
Gonia texensis Rein.	0	0	0	0	0	0	0	0	1	0	1
Gonia spp.†	0	0	1	0	1	1	0	3	1	1	8
Lydella sp.	0	0	0	0	1	0	0	0	0	0	1
Macromeigenia frioensis Rein.	1	0	1	0	1	0	1	0	0	0	4
Microchaetina valida Towns.	0	0	2	0	0	0	0	0	0	0	2
Nemorilla floralis Fall.	0	0	0	0	0	1	0	1	0	0	2
Ormia montana Towns.	0	1	0	2	1	0	0	1	0	0	5
Paradidyma apicalis Rein.	1	0	1	15	1	3	0	2	0	0	23
Paradidyma singularis Towns.	1	4	37	27	18	9	3	55	1	10	165
Paradidyma affinis Rein.	0	0	1	0	0	1	0	1	0	0	3

Table 3 (Continued)

SPECIES OF FLIES	NUMBER OF FLIES IN SAMPLES FROM TYPE-LOCATION NO.										
	1	2	3	4	5	6	7	8	9	10	All Locations
Parlispe infernalis Towns.	0	1	0	1	0	0	0	0	2	0	4
Peleteria obsoleta Curr.	0	0	1	0	19	0	0	0	0	0	20
Peleteria robusta Wied.	6	73	30	73	43	9	22	28	59	4	347
Peleteria townsendi Curr.	0	0	0	0	2	0	0	0	0	0	2
Peleteria spp.†	0	0	0	11	0	0	2	1	0	1	15
Phorocera claripennis Macq.	0	0	1	2	3	7	0	6	2	1	22
Phorocera cinaris Smith	0	0	0	2	0	0	0	0	0	0	2
Phorocera floridensis Towns.	0	1	0	4	0	0	0	3	0	1	9
Phorocera sulcata A. & W.	0	2	8	21	650	8	0	2	12	1	704
Phorocera tachinomoides Towns.	4	12	7	17	22	10	18	87	9	6	192
Phorocera spp.†	0	2	4	2	63	5	0	5	3	0	84
Plagiprospherysa parvipalpis V.d.W.	0	0	1	14	0	5	2	11	0	1	34
Plagiomima spp.	0	0	0	0	0	0	0	0	3	0	3
Pseudochaeta argentifrons Coq.	0	0	0	0	1	0	0	0	0	0	1
Siphosturmia confusa Rein.	0	0	0	0	0	0	0	0	0	2	2
Spathidexia dunningi Coq.	0	2	8	3	2	5	1	2	0	0	23
Sturmia incompta V.d.W.	0	0	0	2	5	1	0	1	0	0	9
Sturmia limata Coq.	0	0	0	0	0	1	0	0	0	0	1
Sturmia protoparcis Towns.	0	0	0	0	0	0	0	1	0	0	1
Sturmia sp.†	0	0	0	0	0	0	0	1	0	0	1
Tachinophyto ancilla Walk.	0	1	2	2	3	3	0	1	0	0	12
Tachinophyto vanderwulpi Towns.	0	1	0	0	0	0	0	0	0	0	1
Tachinomyia robusta Towns.	0	0	0	0	0	0	0	3	0	0	3
Trichopoda pennipes F.	0	0	0	0	0	0	0	1	0	0	1
Viviana spp.	0	0	0	0	2	1	0	1	1	5	10
Voria ruralis Meig.	0	0	0	1	0	2	0	0	2	2	7
Winthemia rufopicta Bigot	0	0	0	1	0	0	0	1	0	0	2
Winthemia texana Rein.	0	1	1	2	0	1	0	0	3	0	8
Zenillia ceratomiae Coq.	0	0	0	0	0	0	1	0	0	0	1
Zenillia confinis Fall.	0	0	0	0	1	1	0	2	0	1	5
Total	47,838	46,067	42,768	42,581	45,809	46,260	41,098	43,186	37,695	47,594	441,011

* In addition to the species of Anthomyiidae listed, 134 undeterminable specimens were included in the sample.
† Species other than those mentioned.
‡ The species of Sarcophagidae listed represent only identified males. Female specimens were not identified. Six specimens representing six new species of *Sarcophaga* not yet described were taken in the traps but these are not included in the list. *Sarcophaga beameri* Hall also occurs in Menard County but it was not taken in the test traps.
§ In addition to the species of Tachinidae listed, 231 undeterminable specimens were included in the samples.

Table 4.—Percentage relationship between the number of flies of each species or group in samples from each location and the total number of each species or group in samples from all locations, 1929–1933.

SPECIES OR GROUP	PER CENT OF FLIES TAKEN IN TYPE LOCATION NO.									
	1	2	3	4	5	6	7	8	9	10
Cochliomyia spp.	11.1	12.3	9.3	8.6	9.2	9.7	10.2	9.2	7.5	12.9
Phormia spp.	11.2	9.7	9.9	10.3	9.9	10.4	9.0	8.9	10.8	9.9
Sarcophagidae	4.6	9.3	14.2	7.5	10.3	9.3	14.2	13.1	8.1	8.4
Cynomyia cadaverina Desv.	12.7	8.6	9.4	11.3	13.2	11.4	12.0	6.4	8.9	6.2
Calliphora coloradensis Hough.	6.6	9.1	9.9	12.2	10.8	12.4	12.5	7.6	8.1	10.7
Calliphora erythrocephala Meig.	21.4	3.6	7.1	7.1	10.7	7.1	14.3	14.3	10.7	3.6
Calliphora latifrons Hough	7.3	7.1	6.5	17.4	11.1	15.6	7.7	2.6	9.1	15.4
Calliphora viridescens Desv.	12.5	9.2	9.9	12.9	9.4	10.1	7.5	6.4	10.6	11.3
Lucilia cuprina Wied.	10.5	21.1	0.0	21.1	15.8	5.3	5.3	5.3	0.0	15.8
Lucilia sericata Meig.	12.8	23.1	2.6	0.0	10.3	12.8	12.8	7.7	2.6	15.4
Lucilia unicolor Towns.	18.0	2.6	6.2	14.1	17.9	18.3	1.9	10.2	6.3	4.5
Cryptolucilia caesarion Meig.	4.7	11.8	9.3	7.5	15.4	4.7	5.7	24.5	10.6	5.7
Musca domestica L.	5.6	37.9	12.7	3.0	4.4	3.0	8.1	9.0	5.0	11.3
Synthesiomyia nudiseta V. d. W.	9.1	8.3	9.2	12.7	15.3	10.5	5.8	12.3	9.6	7.1
Stomoxys calcitrans (L.)	18.2	0.0	27.3	0.0	9.1	0.0	9.1	9.1	9.1	18.2
Muscina stabulans Fall.	6.1	7.6	4.5	21.2	6.1	18.2	4.5	13.6	13.6	4.5
Muscina assimilis Fall.	6.0	6.6	8.6	13.2	6.0	23.8	2.6	16.6	15.2	1.3
Neomuscina tripunctata V. d. W.	5.4	4.2	6.7	29.7	13.7	14.7	4.2	9.3	7.7	4.5
Hydrotaea dentipes F.	41.0	5.1	4.9	13.2	10.7	7.7	3.2	6.8	4.5	2.8
Ophyra aenescens Wied.	22.3	5.4	4.6	7.7	17.7	12.3	7.7	10.8	6.2	5.4
Ophyra leucostoma Wied.	38.2	3.5	2.9	5.8	8.7	9.2	2.3	5.2	2.9	21.4
Chrysomyza demandata F.	3.9	23.5	11.8	9.8	9.8	7.8	11.8	2.0	13.7	5.9
Tachinidae	2.0	6.0	7.7	11.2	38.5	5.6	3.0	14.4	9.0	2.5
Miscellaneous	4.8	7.8	12.4	10.9	8.1	9.1	5.5	23.6	12.2	5.7

in the samples occurs in location 10, while location 9 shows the smallest number of this species. Location 1 exceeds the other locations in the proportionate number of *Phormia* spp. captured, and location 8 has the lowest number of this species.

The percentages given in table 4 indi-

Table 5.—Percentage relationship between the number of flies of each species or group and the number of flies of all species in samples from each location, 1929–1933.

SPECIES OR GROUP	PER CENT OF FLIES TAKEN IN TYPE LOCATION NO.									
	1	2	3	4	5	6	7	8	9	10
Cochliomyia spp.	48.7	53.5	41.7	41.1	40.1	42.1	46.9	40.5	39.4	55.5
Phormia spp.	27.8	24.1	25.2	27.8	24.5	25.7	23.4	22.2	32.4	24.1
Sarcophagidae	6.5	13.0	20.3	11.4	14.3	13.0	20.8	19.6	13.7	11.5
Cynomyia cadaverina Desv.	1.9	1.3	1.5	1.9	2.0	1.7	1.9	1.0	1.6	0.9
Calliphora coloradensis Hough.	1.6	2.1	2.4	3.1	2.5	2.9	3.1	1.8	2.3	2.5
Calliphora erythrocephala Meig.	0.01	0.002	0.004	0.004	0.006	0.004	0.008	0.008	0.007	0.002
Calliphora latifrons Hough	0.07	0.07	0.07	0.2	0.1	0.2	0.08	0.03	0.1	0.2
Calliphora viridescens Desv.	0.1	0.1	0.1	0.2	0.1	0.1	0.09	0.07	0.1	0.1
Lucilia cuprina Wied.	0.004	0.008	0.0	0.009	0.006	0.002	0.002	0.002	0.0	0.006
Lucilia sericata Meig.	0.01	0.02	0.002	0.0	0.008	0.01	0.01	0.006	0.002	0.01
Lucilia unicolor Towns.	10.3	1.5	3.6	8.7	10.2	10.4	1.1	5.8	4.3	2.5
Cryptolucilia caesarion Meig.	0.06	0.1	0.1	0.1	0.2	0.06	0.07	0.3	0.2	0.07
Musca domestica L.	0.1	0.9	0.3	0.08	0.1	0.07	0.2	0.2	0.2	0.3
Synthesiomyia nudiseta V. d. W.	0.5	0.5	0.5	0.8	0.8	0.6	0.3	0.7	0.6	0.4
Stomoxys calcitrans L.	0.004	0.0	0.006	0.0	0.002	0.0	0.002	0.002	0.002	0.004
Muscina stabulans Fall.	0.008	0.01	0.006	0.03	0.008	0.02	0.006	0.02	0.02	0.006
Muscina assimilis Fall.	0.02	0.02	0.03	0.04	0.02	0.07	0.008	0.05	0.05	0.004
Neomuscina tripunctata V. d. W.	0.03	0.03	0.04	0.2	0.08	0.09	0.03	0.06	0.06	0.03
Hydrotaea dentipes F.	0.4	0.05	0.05	0.1	0.1	0.07	0.03	0.06	0.05	0.03
Ophyra aenescens Wied.	0.06	0.01	0.01	0.02	0.05	0.03	0.02	0.03	0.02	0.01
Ophyra leucostoma Wied.	0.01	0.01	0.01	0.02	0.03	0.03	0.008	0.02	0.01	0.07
Chrysomyza demandata F.	0.004	0.02	0.01	0.01	0.01	0.008	0.01	0.002	0.02	0.006
Tachinidae	0.01	0.4	0.5	0.8	2.4	0.3	0.2	0.9	0.07	0.2
Miscellaneous	1.4	2.2	3.6	3.3	2.3	2.5	1.6	6.7	4.1	1.6

Table 6.—Grams of flies of all species caught at each location during different periods of the season for the four-year period, 1929–1932, inclusive; grams and quarts of flies caught at each location during different periods of the 1932–33 season; and the amount of evaporation at each location for the four-year period.

Type-Location No.	Weight of Flies Caught												Evaporation, Apr. 21 to Oct. 21	
	Apr. 1 to May 1		May 2 to Nov. 10		Nov. 11 to Mar. 31		Total for 4 Years	Total for 1932–33 Season	Apr. 1 to May 1, 1932	May 2 to Nov. 10, 1932	Nov. 11, 1932, to Mar. 31, 1933	Total for Season	Four Years	1932–33 Season
	Four Years	1932–33 Season	Four Years	1932–33 Season	Four Years	1932–33 Season								
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Quarts*	*Quarts*	*Quarts*	*Quarts*	*Cc.*	*Cc.*
1	7,505	1,364	13,140	2,561	1,582	391	22,227	4,316	15.0	39.3	8.1	62.4	17,011	3,759
2	3,939	850	9,310	2,285	1,593	280	14,842	3,415	10.8	37.9	5.8	54.5	30,048	5,916
3	3,015	238	7,868	1,941	703	90	11,586	2,269	3.2	30.4	2.0	35.6	24,650	4,749
4	4,471	940	6,560	1,785	1,691	383	12,722	3,108	11.0	27.9	7.6	46.5	20,007	4,002
5	4,922	843	12,204	2,594	1,630	274	18,756	3,711	10.7	38.7	5.8	55.2	21,837	4,004
6	5,721	1,079	8,662	2,198	2,043	314	16,426	3,591	13.9	33.8	6.5	54.2	19,090	3,780
7	3,074	493	6,095	1,488	703	123	9,872	2,104	6.1	23.5	2.8	32.4	31,439	5,556
8	5,127	794	11,557	2,432	1,216	316	17,900	3,542	10.5	38.0	5.2	53.7	26,851	5,375
9	3,753	747	4,225	495	749	123	8,727	1,365	9.0	9.7	2.4	21.1	22,348	3,873
10	4,966	965	14,443	3,678	1,853	406	21,262	5,049	11.4	57.8	8.3	77.5	28,839	5,362
Average	*4,649*	*831*	*9,406*	*2,146*	*1,376*	*270*	*15,432*	*3,247*	*10.2*	*33.7*	*5.5*	*49.3*	*24,212*	*4,638*

Table 7.—Comparative percentages of *Cochliomyia* spp. and *Phormia* spp. in samples taken at each type-location at different periods of the season. Average for four years.

LOCATION No.	APR 1. TO MAY 1		MAY 2 TO NOV. 10		NOV. 11 TO MAR. 31	
	Cochliomyia spp.	*Phormia* spp.	*Cochliomyia* spp.	*Phormia* spp.	*Cochliomyia* spp.	*Phormia* spp.
	Per Cent	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
1	22.8	69.5	65.4	8.4	7.5	69.7
2	24.6	67.2	70.8	5.9	7.9	64.1
3	22.2	67.9	54.8	7.8	4.4	62.6
4	20.1	72.7	56.7	8.2	5.2	62.6
5	20.6	67.9	52.4	7.6	7.5	59.4
6	18.6	71.2	56.5	7.4	6.1	62.0
7	26.5	64.1	63.9	5.8	4.8	61.5
8	24.0	67.3	51.0	5.1	9.7	59.0
9	19.2	73.8	55.7	9.1	5.3	67.0
10	29.9	66.0	73.0	5.2	7.5	67.7
Average	*22.9*	*68.8*	*60.0*	*7.1*	*6.6*	*63.6*

cate the reaction of each species to a particular environment as compared to its reaction to all the other environments studied. For example, of all the *Cochliomyia* captured in all the locations for four years, 12.9 per cent were taken in location 10. Thus it would appear that, on the average, species of this genus are more active in or prefer this type of environment to any other type. On the other hand, locations 1, 9, 4 and 6 seem to be more attractive to *Phormia*.

Data presented in table 5 may be interpreted as indicating the degree of response of each species to the bait under the different environmental conditions. Thus, *Cochliomyia* species responded to the bait in location 10 much more readily than they did in location 9; while, with regard to *Phormia*, the reverse was the case.

In table 6 are given the amount of flies taken and the corrected amount of water evaporation at each location for the four-year period and for the season 1932–33. As screwworm flies caused extreme annoyance during the latter season, it is interesting to note the results obtained for this particular period. The data obtained for the season 1932–33 appear to be closely correlated with those of the four-year period.

From April 1 to May 1 and from November 11 to March 31 the woolmaggot (*Phormia* spp.) flies are the most abundant species, but after May 2 and until November 10 *Cachliomyia* spp. are the predominant forms. After June 1 there is a marked decrease in the amount of flies caught; however, during the period from May 2 to November 10, *Cochliomyia* spp. average about 60 per cent of all flies captured. It is during this season that the greatest damage from myiasis in livestock occurs.

The results given in table 6 show that in

Table 8.—Comparison of type-locations 1 and 10 with reference to the number and percentage of *Cochliomyia* spp. and *Phormia* spp. taken from samples of all flies caught during each season of the test.

LOCATION No.	NUMBER AND PER CENT OF SPECIES TAKEN IN THE SEASONS DESIGNATED							
	1929–30				1930–31			
	Cochliomyia spp.		*Phormia* spp.		*Cochliomyia* spp.		*Phormia* spp.	
	Number	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*
1	5,175	42	3,413	29	6,096	51	2,912	24
10	6,624	51	2,861	22	6,821	55	2,159	17
	1931–32				1932–33			
1	6,769	53	4,205	32	6,465	50	3,497	27
10	7,216	56	3,706	29	7,900	61	3,669	28

locations 1 and 10 the amount of flies caught exceeded that of any other location, both for the 1932–33 season and for the entire four years. During the four-year period, location 1 gave the highest catch, but in 1932–33, a severe screwworm season, trap 10 caught the largest amount. Trap 9 caught the smallest amount of flies during the four-year period and also in 1932–33. It is important to compare the amount of evaporation with the amount of flies caught at each location, considering also the other environmental factors. The evaporation was greatest at location 7. The trap in this location was next to the lowest in the amount of flies caught. Location 2, where the evaporation was next highest, caught about an average amount of flies. Location 10 was the third highest in evaporation, but second highest in the amount of flies caught; however, during the hottest part of the season, when the species of *Cochliomyia* were most abundant, trap 10 in the open sunlight, caught the greatest amount of flies, while trap 9, in dense shade, caught the smallest amount for the same period. At location 1 the evaporation was lowest. The trap in this location caught the greatest amount of flies during the four-year period, but was exceeded by trap 10 in 1932–33.

The density of shade, protection from direct wind, nearness to large ponds or running streams, dryness of the atmosphere and, to some extent, the density of surrounding timber and underbrush appear to be the most influential factors in determining the numbers of the different species inhabiting particular locations. Other factors, such as nearness to houses, barns, corrals, water tanks and elevation, probably bear some influence, but in this study appear to be of minor importance.

The influence of the density of shade on the abundance of different species is well illustrated by comparing locations 9 and 10. The trap in the former was lowest in the amount of flies captured, while that in the latter was next to the highest and in some seasons outranked all others. There seems little reason to doubt that *Cochliomyia* is more abundant or more active under conditions similar to those of location 10. Location 9 ranks second in the number of *Phormia* captured, but under these conditions the abundance of flies seems to be greatly decreased.

A comparison of locations 5, 6 and 7 shows the influence which protection from direct wind and the density, size and kind of surrounding timber bear upon the amount and species of flies attracted to the traps. Of these two factors, protection from direct wind is probably the more important. Locations 5 and 6 were unlike with respect to surrounding vegetation, but were similar in all other factors; location 7 differed from 5 and 6 in having practically no protection from direct wind and only sparse surrounding timber, and was equal with them in other factors considered, except elevation. Location 7 ranked next to the lowest of all in the total amount of flies caught, althought it exceeded 5 and 6 in the number and percentage of *Cochliomyia* spp. taken. The low catch in 7 indicates that there are few flies in such localities. The catches in locations 5 and 6, while above the average, apparently consisted largely of beneficial species, and differed little in the numbers and percentages of *Cochliomyia* spp. and *Phormia* spp.

The writers are of the opinion that proximity to water has very little effect on the numbers of flies unless the body of water is extensive enough to influence markedly the percentage of relative humidity in that vicinity. The amount of flies captured in location 1 and a comparison in the catches of all other locations seem to bear out this point. During normal years the fly population over an area similar to the one in which the test was made is fairly equal in distribution; however, in extremely dry seasons there is probably a decided concentration of flies along the rivers and streams or around large ponds. Generally, *Phormia* seems to prefer such locations.

The dryness of the atmosphere, as measured by water evaporation, undoubtedly affects the abundance and activity of flies. A study of the three locations (7, 2 and 10) where the highest evaporation occurred, and the three (1, 6 and 4) showing the lowest evaporation, indicates that *Cochliomyia* is less influenced by this factor than is *Phormia* or any of the other species.

Table 7 shows the difference between the abundance of *Cochliomyia* spp. and *Phormia* spp. at each location during the seasons when these species are predominant.

The amount of flies and the percentages of *Cochliomyia* spp. and *Phormia* spp. caught are the main points to consider in the selection of locations for blowfly traps. Locations 1 and 10 in this test were outstanding in this respect, and a study of the relative merits of these two locations should afford considerable help in selecting sites for flytraps. Trap 10, in the open sun, 100 yards south of a concrete water tank, with moderate protection from wind and surrounded by timber of medium density, proved superior in its ability to catch screwworm flies, even during the hottest weather, when the species of *Cochliomyia* were predominant. Although this location was somewhat below the average in the percentage of *Phormia*, the greater total amount of flies caught offsets this disadvantage. On the other hand, trap 1 warrants considerable merit in that it caught the largest amount of flies, the greatest number of *Phormia* and the third highest number of *Cochliomyia*. Location 1 was generally similar to location 10 in regard to surrounding timber and protection from wind, but differed from it in being in medium shade and close to a running stream.

In table 8 is given a comparison between locations 1 and 10 in regard to the numbers and percentages of *Cochliomyia* spp. and *Phormia* spp. caught in each of the four years of the test. It is realized that neither of these locations is ideal, as one is better suited to the catching of screwworm flies, while the other is more attractive to those of the woolmaggot. A combination of the more desirable features of each would probably approach the ideal. Thus, a trap in very light shade, near a running stream or large pond of water, protected from direct wind and surrounded with timber and underbrush of medium density, should prove highly efficient in trapping *Cochliomyia* spp. and *Phormia* spp.

CONCLUSIONS.—Blowfly traps placed in the open sunlight, in locations where they are protected from direct wind and surrounded with timber and underbrush of medium density, are more attractive to *Cochliomyia* spp. than are traps in other locations. Woolmaggot flies, *Phormia* spp. prefer more shaded areas and higher humidity, with more surrounding timber and underbrush.

Regardless of other factors, except protection from wind, the species of *Cochliomyia* appear to be more active and abundant in the open sunlight, while *Phormia* spp. seem to prefer medium shade.

Since the comparative abundance of the two species of *Cochliomyia* and species of *Phormia* were not determined for any of the locations, it cannot be stated in which type of location each species was most numerous.—10-3-38.

LITERATURE CITED

Cushing E. C., and W. S. Patton. 1933. Studies on the higher Diptera of medical and veterinary importance. *Cochliomyia americana* C. & P., the screwworm fly of the new world. Am. Trop. Med. and Parasit. 27(4):539-51. Illus.

UNDER authority of Act No. 100 of 1938 of the State of Louisiana, regulating the production, sale, branding and labeling of certified and noncertified seed or other propagating stock, which was approved by the governor on July 2, 1938, the state entomologist issued regulations relating to Irish seed potatoes as to quality, grades and condition as to pests. The regulations became effective September 15.

UNDER an agreement recently reached between state pest control organizations of Arkansas and Missouri, nursery stock can hereafter be moved between these states without any restrictions except the inspection certificate of the state of origin.

THE STATE PLANT BOARD of Florida announced on October 31 the amendment of rule 32 relating to the European corn borer "for the purpose of clarification and to permit movement of restricted materials without unnecessary difficulty from areas in large states, in which areas infestation by European corn borer is not known to occur."

THE white-fringed beetle quarantine regulations of Florida were amended, effective August 25, and those of Alabama, effective October 20. Parts of six Alabama counties are now brought within the infested areas.

A REISSUANCE of the alfalfa weevil quarantine of Kansas, effective October 3, included, as counties designated as infested with the weevil, Weld County, Colo., Banner and Kimball counties, Neb., and the counties of Big Horn, Campbell, Johnson, Sheridan, Washakie and Weston in Wyoming.

Seasonal Variations in the Abundance of *Cochliomyia* spp., *Phormia* spp.* and Other Flies in Menard County, Tex.**

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The seasonal abundance of screwworm and woolmaggot flies is of distinct importance to ranchmen in districts where these pests cause serious loss to the livestock industry. It is desirable to know the time of the year best suited to shearing, marking, castrating, dehorning and tagging animals in order that the loss occasioned by infestations of these flies may be reduced.

Data given in this paper present the results of a four-year study of the fly population in an area of 250 sections of typical ranch land located in the northwest corner of Menard County, Tex. Weather conditions, topography, ranch practices and species and abundance of flies within the district where the work was conducted are generally similar to those in the rest of the Edwards Plateau section of Texas.

SEASONAL OBSERVATIONS.—An analysis of random samples of flies taken on the same day from each of 10 flytraps at different intervals throughout the year furnished the basis for computing the comparative seasonal abundance of the flies under consideration. Some species reported herein are not usually attracted to blowfly traps, and in these cases the data do not indicate the actual abundance of these species.

The traps were operated continuously from April 1, 1929, to March 31, 1933. In this study the period from April 1 of one year to March 31 of the following year was considered as one season. A random sample of 500 flies was taken from the catch of each trap at 10-day intervals from April 1 to October 21, at 20-day intervals from October 22 to January 11, and at 40-day intervals from January 12 to March 31 during each of the four seasons. All flies in these samples were identified as to genus in the case of *Cochliomyia* and *Phormia*, and as to species in practically all others. The entire catch of a trap was used as the sample in cases in which less than 500 flies were captured.

An index of the variations in the total fly population was obtained by weighing the catch of each trap at the end of each seasonal interval.

WEATHER RECORDS.—Minimum and maximum temperatures and rainfall were recorded daily by standard Weather Bureau instruments located at a permanent station in the central part of the county. Atmometers of the Livingston porous-cup type, white and spherical, were operated at each trap location from April 21 to October 21 of each season; their use was discontinued during periods of freezing temperatures. The corrected evaporation was recorded at each seasonal interval.

TRAPS AND BAITS.—Government all-metal, cone-type flytraps were used throughout this work. They were placed in various locations around a circuit of approximately 80 miles within the 250-section area. The traps were baited with 2 pounds of lean beef and 1½ gallons of water. Six cubic centimeters of nicotine sulphate were added to prevent any larvae from developing in the bait. At each emptying date the traps were rebaited with fresh meat and water.

DISCUSSION.—Within the district where this study was made it appears that the temperature and rainfall are the most important factors causing variations in the seasonal abundance of certain flies. It is probable that the greatest variations in fly abundance are due to the interaction of these two factors, although during certain periods of the year each seems to bear a markedly independent influence.

* Certain morphological variations have been noted in the females of the species usually considered as *Phormia regina* Meig. Whether such differences indicate a new species has not been determined, and in this paper *Phormia* spp. refers only to *Phormia regina* and to any other closely related species not yet described. In fig. 1, seasonal variations in the abundance of these species are grouped under the name *P. regina*.

** Since the studies reported herein were completed it has been found that two species have been included heretofore under the name *Cochliomyia macellaria* F. (Cushing & Patton 1933). Field observations have established the fact that while *C. americana* appears to be the primary aggressor in cases of myiasis, it is followed by *C. macellaria*, although the amount of damage caused by the latter species has not been definitely determined. *C. macellaria* is much more abundant than *C. americana*, and both species are taken in traps, the proportion being about 1 of the latter to 3,000 of the former.

† The writers wish to express their gratitude and appreciation to E. W. Laake, under whose direction the work was conducted, for his helpful suggestions and to E. F. Knipling for his assistance in the collection of records.

‡ Early publication of this paper has been secured by payment of the printing charge.

Table 1.—Minimum, maximum and average temperatures, evaporation, and quantity of all species of flies for each seasonal interval; four-year period, April 1, 1929, to March 31, 1933.

Seasonal Intervals		Four-Year Average			Total for Four Years	
No.	Period	Mean Minimum Temperature, Degrees F.	Mean Maximum Temperature, Degrees F.	Mean Temperature, Degrees F.	Evaporation, Cc.	Weight of Flies Caught, Grams
1	4/1 – 4/10	49.4	78.6	64.0	*	13,670
2	4/11– 4/20	52.4	80.3	66.4	*	18,320
3	4/21– 4/30	52.0	78.4	65.2	116.97	14,503
4	5/1 – 5/10	57.2	79.9	68.6	112.93	18,040
5	5/11– 5/20	53.6	81.2	67.4	111.01	16,273
6	5/21– 5/30	59.3	82.4	70.9	102.52	9,294
7	5/31– 6/9	61.8	87.5	74.7	155.39	8,636
8	6/10– 6/19	66.1	91.0	78.6	159.24	5,746
9	6/20– 6/29	68.0	91.6	79.8	142.72	3,150
10	6/30– 7/9	68.6	90.5	79.6	144.17	3,630
11	7/10– 7/19	67.0	92.8	79.8	139.41	4,022
12	7/20– 7/29	66.2	93.5	79.9	187.51	4,583
13	7/30– 8/8	69.5	95.4	82.5	174.28	2,036
14	8/9 – 8/18	66.4	94.6	80.5	171.27	2,251
15	8/19– 8/28	65.6	92.3	79.9	155.49	1,611
16	8/29– 9/7	64.1	88.5	76.3	102.59	1,179
17	9/8 – 9/17	60.2	89.8	75.0	145.06	4,023
18	9/18– 9/27	60.4	84.3	72.4	125.50	1,657
19	9/28–10/7	57.7	81.8	69.8	92.56	2,669
20	10/8 –10/17	51.6	75.7	63.7	82.58	2,024
21	10/18–11/6	45.3	69.5	57.4	*	3,240
22	11/7 –11/26	36.1	60.4	48.3	*	2,672
23	11/27–12/16	32.6	51.9	42.3	*	1,207
24	12/17– 1/5	33.2	57.0	45.1	*	719
25	1/6 – 2/14	36.3	62.9	49.6	*	2,633
26	2/15– 3/31	39.6	66.0	52.8	*	6,532

* Atmometers not operated.

In table 1 it is noted that as we advance from the period February 15 to March 31 to the period April 1 to 10, with a sharp rise in temperature, there is a striking increase in the number of flies taken. This increase continues during the next 10-day

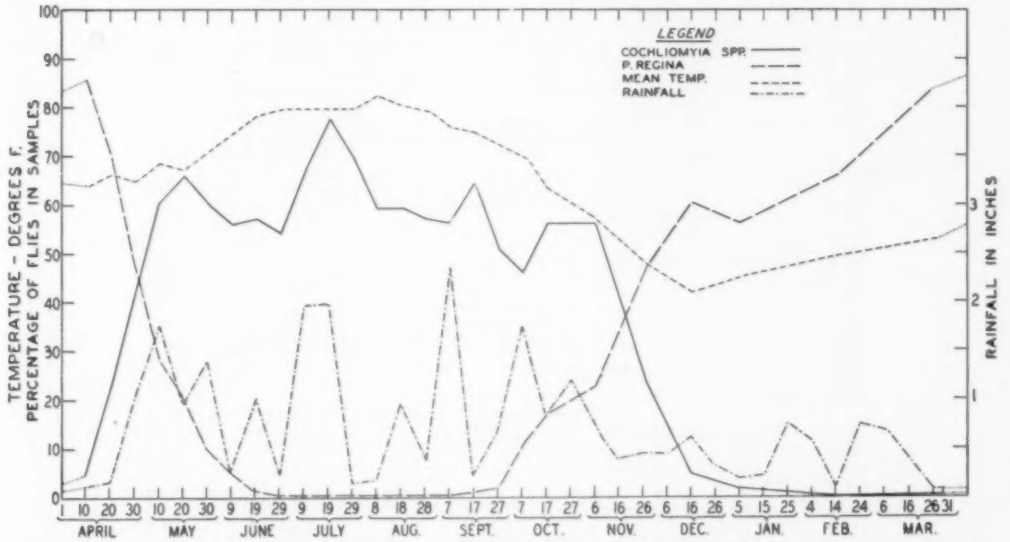

FIG. 1.—Seasonal variations in rainfall and mean temperature, and the comparative abundance of *Cochliomyia* spp. and *Phormia regina*. Average of four years, April 1, 1929, through March 31, 1933.

Table 2.—Number of each species or genus in the total samples for each seasonal interval for four years, April 1, 1929–March 31, 1933.

INTERVALS	NUMBER OF EACH SPECIES IN SAMPLES FROM ALL TRAPS																						
(Intervals identical in date and duration for four-year period)	*Cochliomyia* spp.	*Phormia* spp.	Sarcophagidae	*Cynomya cadaverina* Desv.	*Calliphora coloradensis* Hough	*Calliphora erythrocephala* Meig.	*Calliphora latifrons* Hough	*Calliphora viridescens* Desv.	*Lucilia cuprina* Wied.	*Lucilia sericata* Meig.	*Lucilia mexicana* Macq.	*Cryptolucilia caesarion* Meig.	*Musca domestica* L.	*Syntheriomyia nudiseta* V.d.W.	*Stomoxys calcitrans* (L.)	*Muscina dobulana* Fall.	*Muscina assimilis* Fall.	*Neomusca tripunctata* V.d.W.	*Hydrotaea dentipes* F.	*Ophyra aenescens* Wied.	*Ophyra leucostoma* Wied.	*Chrysomyza demandata* F.	Tachinidae	Miscellaneous spp.	Total flies in samples
4/1 – 4/10	882	17,286	572	13	239	4	2	30	2	2	363	0	4	9	0	2	0	0	15	4	0	0	24	547	20,000
4/11– 4/20	4,321	14,259	536	0	84	0	0	2	1	1	490	0	19	14	0	0	9	1	23	1	0	1	25	213	20,000
4/21– 4/30	8,492	9,693	716	0	35	1	1	4	3	3	503	8	25	34	0	0	6	1	25	3	0	0	56	393	20,000
5/1 – 5/10	12,096	5,923	1,064	0	15	0	0	1	2	0	482	18	13	74	0	4	0	2	10	4	0	0	18	274	20,000
5/11– 5/20	13,263	4,250	1,107	0	3	0	0	0	4	4	848	29	43	76	0	3	1	5	7	5	1	1	99	251	20,000
5/21– 5/30	12,055	2,046	2,121	0	5	0	0	0	1	7	3,008	17	96	79	0	7	0	4	10	8	11	0	59	466	20,000
5/31– 6/9	10,745	983	3,581	0	1	0	0	1	0	11	3,311	8	86	104	0	0	0	17	3	12	7	0	268	452	19,590
6/10– 6/19	11,100	284	4,228	0	3	0	0	0	0	4	2,611	9	38	118	0	2	0	18	0	6	3	1	493	252	19,168
6/20– 6/29	10,078	96	4,738	0	0	0	0	0	1	2	2,837	6	65	139	0	15	0	101	0	6	43	3	122	444	18,696
6/30– 7/9	12,808	85	3,774	0	0	0	0	0	0	2	1,764	2	42	101	0	11	2	28	1	4	22	0	29	325	19,000
7/10– 7/19	15,390	96	3,234	0	0	0	0	0	0	0	641	0	45	157	0	0	1	5	0	0	6	0	41	184	19,800
7/20– 7/29	12,438	37	4,198	0	2	0	0	0	0	1	727	0	32	168	0	1	0	4	0	1	4	2	72	134	17,821
7/30– 8/8	10,592	68	5,389	0	1	0	0	0	1	0	1,310	1	24	165	0	1	1	6	0	2	4	1	92	225	17,883
8/9 – 8/18	10,190	49	5,213	0	0	0	0	0	0	0	779	0	64	135	0	0	1	2	0	2	5	2	371	281	17,094
8/19– 8/28	10,397	135	6,041	0	0	0	0	0	0	1	797	0	33	165	1	0	5	3	0	1	18	2	200	424	18,223
8/29– 9/7	9,987	119	5,021	0	0	0	0	0	0	0	1,623	0	24	208	0	0	22	9	0	1	4	1	44	524	17,587
9/8 – 9/17	12,191	268	3,579	0	1	0	0	0	1	0	1,694	0	116	141	0	0	20	0	4	13	6	10	85	622	18,751
9/18– 9/27	9,717	460	5,166	0	18	0	0	0	2	0	1,716	0	137	297	2	0	12	18	16	30	6	10	349	999	18,955
9/28–10/7	7,865	1,817	3,734	3	132	0	0	0	0	0	1,679	2	133	218	2	12	8	20	35	7	4	4	524	845	17,044
10/8 –10/17	9,020	2,708	2,051	73	196	0	0	0	0	0	871	0	37	84	2	1	11	14	44	4	0	0	75	724	15,915
10/18–11/6	11,188	4,618	908	838	554	0	23	35	1	0	448	30	57	72	4	0	29	32	68	10	1	1	40	1,043	20,000
11/7 –11/26	5,124	9,328	1,121	1,047	1,489	3	22	86	0	0	162	39	89	125	0	6	13	13	25	3	8	2	34	1,261	20,000
11/27–12/16	991	12,166	597	2,065	2,423	4	51	125	0	0	20	257	43	65	0	1	3	7	12	3	19	6	5	846	19,709
12/17– 1/5	240	9,460	532	1,935	2,932	4	76	192	0	0	2	140	1	17	0	0	1	4	13	0	0	4	3	847	16,403
1/6 – 2/14	19	12,925	459	1,429	2,911	11	282	82	0	1	2	36	0	2	0	0	5	0	83	0	1	0	4	1,183	19,435
2/15– 3/31	143	16,515	959	300	860	1	48	16	0	0	82	10	0	3	0	0	1	1	76	0	0	0	7	478	19,500
Total for all intervals	*221,332*	*125,674*	*70,639*	*7,703*	*11,904*	*28*	*505*	*574*	*19*	*39*	*28,770*	*612*	*1,266*	*2,770*	*11*	*66*	*151*	*313*	*468*	*130*	*173*	*51*	*3,139*	*14,237*	*490,574*

Table 3.—Percentage of each species or genus in total samples for each seasonal interval for four years, April 1, 1929–March 31, 1933.

INTERVALS	PERCENTAGE OF EACH SPECIES IN SAMPLES FROM ALL TRAPS																								
(Intervals identical in date and duration for four-year period)	*Cochliomyia* spp.	*Phormia* spp.	Sarcophagidae	*Cynomya cadaverina* Desv.	*Calliphora coloradensis* Hough	*Calliphora erythrocephala* Meig.	*Calliphora latifrons* Hough	*Calliphora viridescens* Desv.	*Lucilia cuprina* Wied.	*Lucilia sericata* Meig.	*Lucilia mexicana* Macq.	*Cryptolucilia cacuarion* Meig.	*Musca domestica* (L.)	*Syntheriomyia nudiseta* V.d.W.	*Stomoxys calcitrans* (L.)	*Muscina stabulans* Fall.	*Muscina assimilis* Fall.	*Neomusca tripunctata* V.d.W.	*Hydrotaea dentipes* F.	*Ophyra aenescens* Wied.	*Ophyra leucostoma* Wied.	*Chrysomyza demandata* F.	Tachinidae	Miscellaneous spp.
4/1 – 4/10	4.41	86.43	2.86	0.07	1.20	0.02	0.01	0.15	0.01	0.01	1.82	0.00	0.02	0.05	0.00	0.01	0.00	0.00	0.08	0.02	0.00	0.00	0.12	2.74
4/11– 4/20	21.61	71.30	2.68	0.00	0.42	0.00	0.00	0.01	0.01	0.01	2.45	0.00	0.10	0.07	0.00	0.00	0.05	0.01	0.12	0.01	0.00	0.01	0.13	1.07
4/21– 4/30	42.46	48.47	3.58	0.00	0.18	0.01	0.01	0.02	0.02	0.02	2.52	0.04	0.13	0.17	0.00	0.00	0.03	0.01	0.12	0.02	0.00	0.00	0.28	1.97
5/1 – 5/10	60.48	29.62	5.32	0.00	0.08	0.00	0.00	0.01	0.01	0.00	2.41	0.09	0.07	0.37	0.00	0.02	0.00	0.01	0.05	0.02	0.00	0.00	0.09	1.37
5/11– 5/20	66.32	21.25	5.54	0.00	0.02	0.00	0.00	0.00	0.02	0.02	4.24	0.15	0.22	0.38	0.00	0.02	0.01	0.03	0.04	0.03	0.01	0.01	0.50	1.26
5/21– 5/30	60.28	10.23	10.61	0.00	0.03	0.00	0.00	0.00	0.01	0.04	15.04	0.09	0.48	0.40	0.00	0.04	0.00	0.02	0.05	0.04	0.06	0.00	0.30	2.33
5/31– 6/9	54.85	5.02	18.28	0.00	0.01	0.00	0.00	0.01	0.00	0.06	16.90	0.04	0.44	0.53	0.00	0.00	0.00	0.09	0.02	0.06	0.04	0.00	1.37	2.31
6/10– 6/19	57.91	1.48	22.06	0.00	0.02	0.00	0.00	0.00	0.00	0.02	13.62	0.05	0.20	0.62	0.00	0.01	0.00	0.08	0.00	0.03	0.02	0.01	2.57	1.31
6/20– 6/29	53.90	0.51	25.34	0.00	0.00	0.00	0.00	0.00	0.00	0.01	15.17	0.03	0.34	0.74	0.00	0.08	0.00	0.54	0.00	0.03	0.23	0.02	0.65	2.37
6/30– 7/9	67.41	0.45	19.86	0.00	0.00	0.00	0.00	0.00	0.00	0.01	9.28	0.01	0.22	0.53	0.00	0.06	0.01	0.15	0.01	0.02	0.12	0.00	0.15	1.71
7/10– 7/19	77.73	0.48	16.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.24	0.00	0.23	0.79	0.00	0.00	0.01	0.03	0.00	0.00	0.03	0.00	0.21	0.93
7/20– 7/29	69.79	0.21	23.56	0.00	0.01	0.00	0.00	0.00	0.00	0.01	4.08	0.00	0.18	0.94	0.00	0.01	0.00	0.02	0.00	0.01	0.02	0.01	0.40	0.75
7/30– 8/8	59.23	0.38	30.13	0.00	0.01	0.00	0.00	0.00	0.01	0.00	7.33	0.01	0.13	0.92	0.00	0.01	0.01	0.03	0.00	0.01	0.02	0.01	0.51	1.26
8/9 – 8/18	59.61	0.29	30.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.56	0.00	0.37	0.79	0.00	0.00	0.01	0.01	0.00	0.01	0.03	0.01	2.17	1.64
8/19– 8/28	57.05	0.74	33.15	0.00	0.00	0.00	0.00	0.00	0.00	0.01	4.37	0.00	0.18	0.91	0.01	0.00	0.03	0.02	0.00	0.01	0.10	0.01	1.10	2.33
8/29– 9/7	56.79	0.68	28.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.23	0.00	0.14	1.18	0.00	0.00	0.13	0.05	0.00	0.01	0.02	0.01	0.25	2.98
9/8 – 9/17	65.02	1.43	19.09	0.00	0.01	0.00	0.00	0.00	0.01	0.00	9.03	0.00	0.62	0.75	0.00	0.00	0.11	0.00	0.02	0.07	0.03	0.05	0.45	3.32
9/18– 9/27	51.26	2.43	27.25	0.00	0.09	0.00	0.00	0.00	0.01	0.00	9.05	0.00	0.72	1.57	0.01	0.00	0.06	0.09	0.08	0.16	0.03	0.05	1.84	5.27
9/28–10/7	46.15	10.66	21.91	0.02	0.77	0.00	0.00	0.00	0.00	0.00	9.85	0.01	0.78	1.28	0.01	0.07	0.05	0.12	0.21	0.04	0.02	0.02	3.07	4.96
10/8 –10/17	56.68	17.02	12.89	0.46	1.23	0.00	0.00	0.00	0.00	0.00	5.47	0.00	0.23	0.53	0.01	0.01	0.07	0.09	0.28	0.03	0.00	0.00	0.47	4.55
10/18–11/6	55.94	23.09	4.54	4.19	2.77	0.00	0.12	0.18	0.01	0.00	2.24	0.15	0.29	0.36	0.02	0.00	0.15	0.16	0.34	0.05	0.01	0.01	0.20	5.22
11/7 –11/26	25.62	46.64	5.61	5.24	7.45	0.02	0.11	0.43	0.00	0.00	0.81	0.20	0.45	0.63	0.00	0.03	0.07	0.07	0.13	0.02	0.04	0.01	0.17	6.31
11/27–12/16	5.03	61.73	3.03	10.48	12.29	0.02	0.26	0.63	0.00	0.00	0.10	1.30	0.22	0.33	0.00	0.01	0.02	0.04	0.06	0.02	0.10	0.03	0.03	4.29
12/17– 1/5	1.46	57.67	3.24	11.80	17.87	0.02	0.46	1.17	0.00	0.00	0.01	0.85	0.01	0.10	0.00	0.00	0.01	0.02	0.08	0.00	0.00	0.02	0.02	5.16
1/6 – 2/14	0.10	66.50	2.36	7.35	14.98	0.06	1.45	0.42	0.00	0.01	0.01	0.19	0.00	0.01	0.00	0.00	0.03	0.00	0.43	0.00	0.01	0.00	0.02	6.09
2/15– 3/31	0.73	84.69	4.92	1.54	4.41	0.01	0.25	0.08	0.00	0.00	0.42	0.05	0.00	0.02	0.00	0.00	0.01	0.01	0.39	0.00	0.00	0.00	0.04	2.45
Percentage for all intervals	*45.12*	*25.62*	*14.40*	*1.57*	*2.43*	*0.01*	*0.10*	*0.12*	*0.004*	*0.01*	*5.86*	*0.12*	*0.26*	*0.56*	*0.002*	*0.01*	*0.03*	*0.06*	*0.10*	*0.03*	*0.04*	*0.01*	*0.64*	*2.90*

period, giving a maximum collection recorded for the four-year period. During the following 10-day period, although the rainfall showed a continued increase, a slight drop in temperature was accompanied by a decrease in the quantity of flies caught. The period from May 1 to 10, in which there were increases in both temperature and rainfall (table 4.) showed an increase in abundance of flies. Thereafter the fly population dropped to approximately 50 per cent, or less, of the maximum. This rapid decrease is due to the great reduction in the number of *Phormia* spp. and other cool-weather species with the advent of higher temperatures. It is of particular interest to note that from May 11 until September 17 a check in the normal decrease of rainfall or an increased amount of rainfall was usually followed, 10 days later, by either a check in the normal decrease in the number of flies or an increase in their number. From May 31 to September 17 of this period the average mean maximum temperatures did not vary more than 8 degrees.

Table 4.—Rainfall in inches for each 10-day interval for four years, April 1, 1929, to March 31, 1933.

Intervals	Seasons				Mean Rainfall
	1929–30	1930–31	1931–32	1932–33	
4/1 – 4/10	0.49	0.00	0.04	0.00	0.13
4/11– 4/20	0.00	0.03	0.59	0.00	0.16
4/21– 4/30	0.00	0.90	1.38	1.71	1.00
5/1 – 5/10	1.28	0.68	0.03	5.05	1.76
5/11– 5/20	2.67	0.41	0.15	0.68	0.98
5/21– 5/30	3.79	0.09	0.65	1.11	1.41
5/31– 6/9	0.04	0.24	0.00	0.75	0.26
6/10– 6/19	0.00	2.17	1.47	0.39	1.01
6/20– 6/29	0.65	0.00	0.28	0.20	0.26
6/30– 7/9	2.00	0.00	2.96	2.91	1.97
7/10– 7/19	0.15	0.03	7.83	0.00	2.00
7/20– 7/29	0.51	0.00	0.00	0.13	0.16
7/30– 8/8	0.00	0.21	0.00	0.57	0.20
8/9 – 8/18	0.00	0.31	2.42	1.13	0.97
8/19– 8/28	0.00	0.33	0.37	1.01	0.43
8/29– 9/7	2.53	0.00	2.36	4.61	2.38
9/8 – 9/17	0.09	0.84	0.00	0.00	0.23
9/18– 9/27	0.00	0.00	0.00	2.70	0.68
9/28–10/7	0.00	6.62	0.00	0.50	1.78
10/8 –10/17	2.24	0.63	0.30	0.24	0.85
10/18–10/27	1.85	1.32	1.45	0.22	1.21
10/28–11/6	0.14	0.63	0.00	2.14	0.73
11/7 –11/16	0.41	1.15	0.07	0.00	0.41
11/17–11/26	0.11	0.00	1.66	0.06	0.46
11/27–12/6	0.00	1.09	0.59	0.11	0.45
12/7 –12/16	0.86	0.07	1.04	0.51	0.62
12/17–12/26	0.03	0.25	0.12	0.97	0.34
12/27– 1/5	0.00	0.38	0.39	0.03	0.20
1/6 – 1/15	0.11	0.35	0.00	0.46	0.23
1/16– 1/25	0.00	1.90	1.03	0.16	0.77
1/26– 2/4	0.04	2.09	0.00	0.22	0.59
2/5 – 2/14	0.00	0.59	0.05	0.00	0.16
2/15– 2/24	0.00	0.77	2.21	0.00	0.75
2/25– 3/6	0.18	0.16	0.72	1.72	0.70
3/7 – 3/16	0.00	1.52	0.17	0.00	0.42
3/17– 3/26	0.19	0.20	0.00	0.00	0.10
3/27– 3/31*	0.17	0.06	0.00	0.13	0.09

* March 27 to 31, five-day periods.

There appears to be no definite relationship between variations in evaporation and fly population.

The comparative abundance of each species or genus during each of the 10-, 20- and 40-day intervals is given in tables 2 and 3.

The rainfall, in inches, for each 10-day interval for four years April 1, 1929, to March 31, 1933, is given in table 4.

Fig. 1 shows the seasonal variation in rainfall and mean temperature and the relation of these factors to variations in the comparative abundance of *Phormia* spp. and *Cochliomyia* spp., averaged for four years.

The population of *Phormia* appears to follow a definite trend from season to season and is not greatly affected by varying periodic weather conditions. All data used in the following discussion are averages taken from the four-year test in question and may not apply to a single season. Beginning about September 7 the numbers of *Phormia* spp. show an almost unbroken increase until the maximum is reached during the early part of April. The number rapidly decreases after April 10. *Phormia* spp. are the predominant species caught in flytraps from about November 16 to about April 30, or for approximately 165 days of the year.

During the season from May 1 to November 16, when *Cochliomyia* spp. are predominant, the population of this genus is considerably affected by changing weather conditions. It is noted that from April 1 to May 20 the abundance follows closely the rise in temperature and amount of rainfall, although the peak is not reached until 10 days after the period of maximum rainfall. For 20 days after May 20 there is a marked falling off in the comparative abundance of *Cochliomyia* spp., due, apparently, to a diminishing precipitation. From May 20 until July 29 the abundance varies with the rainfall. The greatest number of *Cochli-*

omyia in the total fly population is attained during the period July 9 to 19. After July 29 and until November 6 periods of high rainfall are accompanied by decreased abundance of *Cochliomyia* spp. The decreasing temperature after November 6 causes a rapid decline in the number of flies of this genus.

CONCLUSIONS.—The importance of ascertaining the seasonal abundance and activity of screwworms and woolmaggot flies is appreciated when it is understood that a great percentage of infestations from these pests may be avoided by changing the time of conducting certain ranch operations which would induce screwworm attack.

Data presented in this paper indicate that during the four years covered by these records four main peaks in the comparative abundance of *Cochliomyia* spp. occurred during each season: Namely, May 10 to 20, July 9 to 19, September 7 to 17 and October 17 to November 6.

Our observations in Menard County show there are very few screwworm cases in livestock prior to May 10. Therefore, we are of the opinion that such operations as shearing, marking, castrating, and dehorning should be completed and animals bred so the young will drop before this date. The time of year best suited for fall shearing of sheep and goats appears to be the last 10 days of August or after September 27 and before October 17. Sheep should be "tagged" (wool trimmed from breech) during the latter part of February or early in March to avoid possibility of infestations of woolmaggots.—10-3-38.

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Soil Sterilization Experiments on Killing Larvae of the White-Fringed Beetle, *Naupactus leucoloma* Boh.

L. L. ENGLISH and C. P. GRAHAM,*† *Alabama Agricultural Experiment Station, Auburn*

The white-fringed beetle, *Naupactus leucoloma* Boh., was first found in Alabama in 1936 near Lockhart. Due to the potential seriousness of this pest, the infested area was quarantined in 1937. This necessitated the treatment of the balled nursery stock before it could be moved from this area.

The most extensive work on the control of soil insects is that done by Fleming & Baker (1935) with the Japanese beetle. These workers found that Japanese beetle larvae could be killed in the soil about nursery plants by treatment before digging. Their method was to pour dilute carbon disulfide emulsion into sheet iron hoops surrounding the plants two days before digging. On a commercial basis this was found to kill all the larvae in about 95 per cent of the stock, under favorable conditions. They recommended that the stock emulsion‡ be diluted at different rates, depending upon the temperature of the soil 6 inches below the surface. Recommended dilutions at various temperatures are listed in table 1.

Table 1.—Recommended dilutions of carbon disulfide emulsion for treatment of Japanese beetle at various soil temperatures.

STOCK EMULSION PER GALLON OF WATER	MINIMUM SOIL TEMPERATURES
6.8 cc.	40–50 degrees F.
5.7 cc.	50–60 degrees F.
4.5 cc.	60–70 degrees F.

The diluted emulsion was used at the rate of 2.5 gallons per square foot of soil.

Because of the extensive work of Fleming & Baker, and because of the

* The authors are indebted to Mr. H. C. Young and others of the U. S. Bureau of Entomology and Plant Quarantine for help and cooperation in this work.
† Early publication of this paper has been secured by payment of the printing charge.

‡ Formula 10, A "Soluble oil" type of emulsion containing 50 per cent carbon disulfide.

similarity of the Japanese beetle problem to that of the white-fringed beetle, the first experiments were made with carbon disulphide emulsion.

HOOP METHOD EXPERIMENTS WITH CARBON DISULFIDE EMULSION.—Sheet iron hoops 18 inches in diameter and 10 inches high were driven into the soil in an infested field to a depth of 3 inches. Five gallons of dilute emulsion were used in each hoop instead of the exactly-calculated quantity of 4.4 gallons. The soil was a sandy loam with yellow clay at a depth of about 6 inches and the soil temperature was approximately 75 degrees F. at this depth.

Three areas were treated with each dosage so that examinations could be made at 24, 48 and 72 hours after treatment. The soil was removed from the hoops with a cup and carefully examined for larvae. The larvae found were placed in metal boxes and observed for 24 hours before final records were made.

Table 2.—Toxicity of carbon disulfide emulsion to larvae of *Naupactus leucoloma* Boh. by the hoop method.

QUANTITY OF EMULSION PER GALLON OF WATER	PER CENT DEAD AFTER		
	24 Hours	48 Hours	72 Hours
3.3 cc.	73	91	78
4.5 cc.	97	80	93
5.7 cc.	97	88	76

From the results shown in table 2, it will be seen that this insecticide was not 100 per cent effective in any case. It should be noted that, with the exception of the lowest, the concentrations used were in excess of that recommended for the Japanese beetle by Fleming & Baker for the prevailing soil temperature.

In another experiment with the soil at a temperature of 86 degrees F., a dosage of 7 cubic centimeters per gallon of water killed 88 per cent of the larvae. Later in the fall when the soil was cooler, a dosage of 30 cubic centimeters per gallon of water killed only 46 per cent of the larvae.

IMMERSION EXPERIMENTS WITH CARBON DISULFIDE EMULSION AND OTHER INSECTICIDES.—When it was found that earth balls could be wrapped tightly with burlap and submerged in water without losing the soil, a series of tests was started to determine if this more simple and direct method of treatment would be effective. Balls of earth about 12 inches in diameter were dug from an infested field. Almost without exception enough larvae were obtained in each ball for a reliable test. After the balls were submerged in the liquid, they were drained and allowed to stand for a minimum of 48 hours before examination. To facilitate examination for larvae the burlap was removed and the balls were placed in 10-gallon garbage cans to which about 8 gallons of water were added. This was stirred thoroughly and allowed to settle for a few minutes. The water above the soil was then dipped out and poured through a sieve. Practically all of the larvae in a ball of earth could be efficiently removed by this method.

The results of submerging infested earth balls in carbon disulfide emulsion at various concentrations are shown in table 3. At 40 cubic centimeters per gallon of water the emulsion was very effective, giving a kill of 100 per cent in three out of four tests. It should be noted that the time the balls were submerged showed no variation in effect. By observation it was found that the liquid penetrated the earth in approximately 5 minutes.

Cherry laurel (*Laurecerasus caroliniana*), wax privet (*Ligustrum lucidum*), Rosedale arbor vitae (*Thuja* sp.), and *Retinospora* (*Chamaecyparis*) *ericoides*, were all killed by 5.7 cubic centimeters of carbon disulfide emulsion per gallon of water when treated by the hoop method. Wax privet, Rosedale arbor vitae, boxwood (*Buxus* sp.), and *Abelia grandiflora* were killed when the earth balls dug with these plants were submerged for 10 minutes in carbon disulfide emulsion at the rate of 40 cubic centimeters per gallon of water.

A list of other insecticides and chemicals which also gave negative results on the larvae in earth balls is given in table 4. From this table it will be seen that none of the common contact insecticides, at rather excessive dosages, gave satisfactory control; the powerful stomach poison, sodium arsenite, also gave poor results.

EXPERIMENTS WITH POTASSIUM CYANIDE.—Of the many insecticides tested, potassium cyanide was the only one which showed definite toxicity to the larvae in balls of earth. The results of an experiment with this chemical are given

Table 3.—Toxicity of carbon disulfide emulsion to larvae of *Naupactus leucoloma* Boh. by the earth-ball immersion method.

Cubic Centimeters of Carbon Disulfide Emulsion per Gallon of Water	Minutes Immersed	Hours Until Examination	Number of Larvae Found	Per Cent Kill
10	15	72	13	15
10	15	212	12	42
10	15	336	9	67
10	15	408	14	72
15	30	48	9	67
20	10	48	19	90
20	30	48	15	80
30	10	48	7	57
30	30	48	7	71
40	5	48	9	100
40	10	48	13	72
40	15	48	8	100
40	30	48	9	100
Untreated check		408	8	0

in table 5. It will be noted that this chemical was highly toxic to the larvae. In a subsequent experiment when the soil moisture was higher, it was found that 40 grams per gallon of water was the minimum concentration that would give 100 per cent kill.

It was very interesting to find that larvae removed from the soil, placed in cloth bags and dipped into KCN were not readily killed. Only 20 per cent of the larvae submerged in a solution of KCN, 40 grams per gallon of water, for 15 minutes were killed. A concentration of 20 grams per gallon of water killed none of the larvae. This would seem to indicate that the

Table 4.—Toxicity of various insecticides to larvae of *Naupactus leucoloma* Boh. by the earth-ball immersion method.

Insecticide	Dilution	Per Cent Kill*
Derris extract (pine oil)	20 cc. per gal. of 1–500 IN438†	23
Derrisol	8 cc. per gal. of 1–500 IN438†	17
Cubé root	19 gm. per gal. of 1–500 IN438†	10
Pyrethrum	20 gm. per gal. of 1–500 IN438†	20
Nicotine sulfate	20 cc. per gal. of 1–500 IN438†	9
Foliafume	20 cc. per gal. of 1–500 IN438†	13
Lethane 440	20 cc. per gal. of water	69
Lethane 440	40 cc. per gal. of water	25
C. P. 100	20 cc. per gal. of water	0
C. P. 100	40 cc. per gal. of water	0
Loro	10 cc. per gal. of water	25
Loro	20 cc. per gal. of water	38
Loro	40 cc. per gal. of water	32
Turpentine emulsion	20 cc. per gal. of water	0
Turpentine emulsion	40 cc. per gal. of water	8
Formalin (37% CH_2O)	20 cc. per gal. of water	0
Sodium arsenite	20 cc. per gal. of water	10
Nursery volck	1–25	0
Nursery volck	1–50	0
Nursery volck	1–50 plus cubé root 1–200	0
Nursery volck	1–50 plus nicotine sulfate 1–200	0
Florida volck	1–8	90
Liquid lime sulfur	1–8	20
Liquid lime sulfur	1–8 plus nicotine sulfate 1–200	6

* All earth balls were submerged for 15 minutes and examined 48 hours later.
† A sulfated alcohol manufactured by DuPont.

toxicity of the KCN to larvae in the soil was due to the reaction with soil acids to liberate HCN within the soil mass. Nevertheless, the effectiveness of KCN to larvae in the soil was not materially increased by the addition of a small quantity of hydrochloric or sulfuric acid to the solution before dipping. Potassium cyanide solution was very toxic to plants, and efforts to eliminate plant injury by submerging the earth balls in running water and very

Table 5.—Toxicity of potassium cyanide to larvae of *Naupactus leucoloma* Boh. by the earth-ball immersion method. Balls submerged for 15 minutes at 85 degrees. F.

Quantity of KCN per Gallon of Water	Per Cent Dead After	
	48 Hours	72 Hours
40.0 grams	100	100
20.0 grams	99	100
10.0 grams	86	100
5.0 grams	83	100
2.5 grams	—	90

weak acids after treatment with KCN were negative. Even at 5 grams per gallon of water, KCN killed Florida jasmine, Rosedale arbor vitae and wax privet.

As a means of treating soil which does not contain plants, KCN offers considerable promise.

Experiments with Petroleum Fractions.—Infested earth balls were submerged in white gasoline, cleaning naphtha and fuel oil. Such treatment did not always give 100 per cent kill and the plants were always killed, although a number of schemes were tried in an effort to avoid plant injury.

Experiments with Fumigants.—Infested earth balls were confined in large paper bags for various periods of time with *Cyanogas G-Fumigant*, paradichlorobenzene, naphthalene and carbon disulfide, at somewhat excessive dosages, with negative results.

Hot Water and Steam Treatment.—The earth balls were submerged in a barrel of water, the temperature of which was kept nearly constant by means of an electric heater with a thermostat and an electric stirrer.

It was soon found that submergence of the balls of earth for less than an hour would not heat the interior sufficiently to kill the larvae. There was always a differential of 25 to 30 degrees between the temperature of the water bath and the minimum temperature inside the ball. Clay portions remained lower in temperature than the sandy portion of the ball. A few data are given in table 6.

It will be noted that a perfect kill was obtained in all four of the balls submerged in hot water at 135 degrees F. for an hour. Submergence in water at lower temperatures gave unreliable results. Efforts to obtain more nearly uniform heating by pumping hot water and by forcing steam through the balls were negative. These measures also tended to disintegrate the balls.

In tests with bagged and balled azaleas, submergence of the earth ball in a water bath at 115 degrees F. for 15 minutes was the maximum exposure from which the plant survived. Rosedale arbor vitae and wax privet were killed when the earth balls were submerged in water at 140 degrees F. for an hour. These two species were also killed by a 20-minute injection of steam, which was the required steam treatment to give a 99 per cent kill of the larvae.

A series of tests was run to determine the temperature of water required to kill the larvae when they were removed from the soil and submerged in the water in small cloth bags. Submergence of the larvae in water 130 degrees F. or higher for

Table 6.—The toxicity of hot water to larvae of *Naupactus leucoloma* Boh. in balls of earth.

Number of Balls Treated	Temperature of Water, in Degrees F.	Average Minimum Temperature in Degrees F. Inside Ball After Treatment	Per Cent Kill*
4	135	106	100
3	130	95	93
1	120	—	63
1	110	—	64

* All of the balls were submerged for one hour.

one minute always gave a perfect kill. Below 130 degrees F. a perfect kill was not always obtained with this short exposure. At 120 degrees F. submergence for 5 minutes gave 100 per cent kill; 15 minutes, 80 per cent; and 30 minutes, 100 per cent. At 115 degrees F. for 5 minutes none of the larvae was killed. At 110 degrees F. for 15 minutes none was killed,

but for 60 minutes a perfect kill was obtained. A temperature of 105 degrees F. for 60 minutes killed only 10 per cent of the larvae.

HEATING EARTH BALLS DIRECTLY WITH ELECTRICITY.—Tavernetti (1935), Newhall & Nixon (1935) and others have designed and experimented with devices for sterilizing soil with the heat generated by passing an electric current directly through the soil. Considerable time was devoted to an attempt to adapt this method to balled nursery stock.

The general procedure was to dig infested balls and tightly wrap them in burlap. They were then submerged in an electrolyte solution (muriate of potash) for five minutes to increase the conductivity of the soil; placed between sheetiron electrodes and the current applied. In this manner a 12-inch earth ball dipped in a 2 per cent solution of KCl was heated with a 220-volt current to a minimum inside temperature of 110 degrees F. in four minutes. Lower concentrations of KCl increased the time required for heating. In these experiments, several concentrations of KCl were used and many electrode arrangements were tried but there was always a lack of uniformity of heating, due to the variation in soil texture and moisture. Temperature differences of from 25 to 100 degrees F. in the same ball were obtained. One of the methods tried was to cover the infested and wrapped earth ball with moist sand in a box fitted with sheetiron electrodes. This also failed to give uniform heating.

More work along this line probably should be done, much lower voltages and more time for the heating being used. Voltages of 110 and higher provide a definite hazard to the operator in this kind of work. Unless proper insulation of equipment is provided, an entire building may become energized, making it dangerous for others than the operator.

SUMMARY.—Experiments with a number of insecticides for sterilizing soil containing larvae of the white-fringed beetle gave negative results at concentrations which were safe to nursery plants. Potassium cyanide in aqueous solution was the only chemical that showed definite toxicity to the larvae in the soil. This chemical offers promise for sterilizing soil that does not contain plants. Results with hot water, steam and electrical heating devices were negative.—10-14-38.

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The Dedication of Mexico's Leland Ossian Howard Entomological Laboratory*

JOSEPHUS DANIELS, *U. S. Ambassador to Mexico*

I regard it as both an honor and a privilege to speak for my countrymen upon the occasion when Mexican men of letters and scientific attainment have given a signal token of esteem and appreciation to a distinguished American scientist. It is rare that any nation bestows permanent distinction upon a great man of another country by giving his name to one of its buildings. In this act Mexico records its acknowledgment, in its National Polytechnic Institute, that scientific discoveries are the possession of all men in every clime, and makes this recognition in an enduring and visible form.

You are gathered today, under the approval of the Secretary of Public Education, to do honor to three great men of two nations who have made contributions to human progress not only to their own countries, but also to all mankind: the

* Excerpts from address by Ambassador Josephus Daniels on the occasion of the inauguration of the Entomological Laboratory, *Leland Ossian Howard* of the National School of Biological Sciences of Mexico; delivered in the auditorium of the National Polytechnic Institute, Saturday, September 3, 1938.

illustrious Louis Pasteur, the greatest man of science of France; Emile Brumpt, French parasitologist of world fame; and Leland Ossian Howard of the United States. This trinity of thinkers and leaders belongs to the world, and the recognition of them here today illustrates the truth of a recent important statement by President Roosevelt. He said: "Civilization is not national—it is international—even though that observation, trite to most of us, is today challenged in some parts of the world. Ideas are not limited by territorial borders; they are the common inheritance of all free people. Thought is not anchored in any land; and the profit of education redounds to the equal benefit of the whole world. That is one form of free trade to which the leaders of every opposing political party can subscribe."

For centuries, mountains and rivers and oceans were the material barriers separating countries and peoples. Later, as these barriers gave way to invention, tariff walls, edifices of ignorance and prejudice, the barricades of super-nationalists, the fetish of the fortress of self-sufficiency, the attempt to erect walls to prevent or check the passage of the thoughts of one nation to the peoples of other countries, and other obstructions and obstacles to the enjoyment by all of the discoveries of all were raised in the vain attempt to emulate the example of King Canute, who impotently essayed to stay the on-coming ocean. But just as certain as knowledge has indestructible wings, no barricades can be erected high enough to impede the universal enjoyment of the discoveries of science and the inventions of men of genius.

I am proud that my country, in the person of Dr. Leland Ossian Howard, has been signaled for distinction by fellow-scientists in this neighbor country. Dr. Howard highly appreciates the designation of honor you have conferred upon him, and sincerely regrets that he is denied the privilege of being present and sharing in the exercises of this important day in the history of the National School of Biological Sciences. As a poor substitute, I wish to convey his gratitude for a recognition that warms his heart and to thank you, both in his behalf and in the name of my country, to which his long zeal and discoveries have brought this tribute.

For 33 years Dr. Howard gave the full measure of his zeal and learning to service in the Bureau of Entomology, and has been declared "the greatest entomologist in the world today." Two campaigns with which Dr. Howard has been identified are especially widely known. He was a leader in the mosquito crusade. As early as 1893 he published results of the use of kerosene, and when the mosquitoes were identified as disease carriers he was able to recommend methods of control. His publications on the housefly, dating from 1896 to his book, *The Housefly, Disease Carrier*, in 1911, were largely responsible for the anti-housefly crusades all over the world in the last 20 years.

Dr. Howard is a member of the National Academy of Sciences, the American Philosophical Society, and the American Academy of Arts and Sciences. He was permanent Secretary of the American Association for the Advancement of Science for 22 years, and was President in 1920–21. He has been made an honorary member of many foreign scientific societies (24 foreign and 20 American scientific societies), is the only American member of the Academy of Agriculture of France, and has received several decorations, among them the cross, *Chevalier de la Legion d'Honneur*, and the Cross, *Officer de l'Ordre du Merite, Agricole*. He has been delegate to many international assemblies and an officer of six scientific gatherings (international scientific congresses).

Mexico's appreciation of Dr. Howard and Dr. Howard's appreciation of Mexico show there is reciprocity among men of science in both countries. In his *History of Applied Science*, Dr. Howard expresses the obligation he and other scientists owe to Mexico. He wrote:

"Mexican officials have always been exceedingly courteous to American official entomologists who have visited that country on various commissions connected especially with the investigation of the boll weevil, the pink bollworm and the orange fruit-worm, and have shown the most intelligent and cordial wish to close cooperation."

In fact, American entomologists who made research and scientific trips to Mexico were never afterward subjected to trouble such as Dr. Howard relates came to him during his first trip to Mex-

ico. He relates when he was under suspicion as a potential bank robber:

"It might be worth while also to mention that I was myself arrested in Cordoba while collecting insects at night on the white wall of a building under an arc light. I had climbed up on a barred window to reach a highly placed specimen, when I was caught by the police and carried off to the *cuartel*. I showed my specimens and tried to explain, but without effect. I had met the Jefe Politico in the morning and had his card in my pocket. When I produced it, they sent for the high official, who liberated me with apologies and who later gave me an official document entitling me to the freedom of the city and the right to collect insects anywhere. The point of the whole episode was that the building on which I was climbing was the principal bank of the town."

This extract is quoted to disprove the misconception as to scientists held by some people otherwise well informed. They seem to think that these men who devote their lives to fighting bugs and other enemies of men spend their whole time pleasantly in laboratories with their experiments and their books. The experience of Dr. Howard shows that these men who have wrought so much for the homfort and health of their fellowmen pave found it necessary to associate with oests which war against human beings in crder to exterminate them or to find ways to circumvent their bites and poison, even risking imprisonment to obtain specimens. The dangers to which entomologists are exposed recall the lines of De Morgan in *A Budget of Paradoxes:*

"Great fleas have little fleas upon their backs to bite 'em,
And little fleas have lesser fleas—so on, *ad infinitum*,
And great fleas themselves in turn, have greater fleas to go on;
While these again have greater still, and greater still, and so on."

Scientists and doctors like Dr. Walter Reed and the altruistic victims who converted their bodies as specimens for experiment in the war against yellow fever are of the aristocracy of science, in which Pasteur, Howard, Brumpt are shining lights. They deserve high places in the Hall of Fame.

Swift declared that "whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together." Without debating this appraisement of farmer and politician, is it not clear that the entomologists who discovered ways to destroy the bugs and the other insects that prey on growing crops, and other disease-breeding mosquitoes and flies, deserve at least as much of mankind as the agriculturist who multiplies the yield on his farm?

Conferring the name Howard upon your entomological laboratory is but one of many significant acts which bind Mexico and the United States together in common devotion to culture and science. The stronger these mutual bonds, the surer is the spirit of the Good Neighbor advanced and undergirded both sides of the Rio Grande.

Tour to the Entomological Congress

EDITH M. PATCH, *President, American Nature Study Society, Orono, Me.*

Participants in the "long tour" to the International Congress of Entomology at Berlin sailed from Montreal the last week in June and returned to the United States toward the end of September. A three-months panorama, vivid in the memory of the members of the party, includes fascinating vistas of North Ireland, Eire, Wales, England, Norway, Sweden, Denmark, Germany and Austria of the Deutsches Reich, Poland, Czechoslovakia, Hungary, Switzerland and France.

The enjoyable hours spent in an incredibly large number of castles, cathedrals, museums and palaces demonstrated that the tour was remarkably well-planned. A dash of opera or theatre was indulged in here and there: the Abbey

Theatre Company, which has been welcomed in America, in their own Abbey Theatre in Dublin; *The Insect Play*, by the Brothers Capek, and Gilbert and Sullivan's *Mikado* in London; grand opera in Munich and again in Paris. The historic background of most of the places visited was offered us in suitable doses. Interesting meals in famous old inns frequently varied the hotel routine.

But it was not only "that sort" of tour. In contrast to the usual schedule followed by "trippers," were the days passed in places not often found by sightseers. There was the charm of Achill Island, known to discerning artists. It was here an old Irishman told us, "I am very sorry for people who live in Yankee Land where there is such a bad government that you can lose money by putting it into banks. Now, in Eire that is impossible. We have a *good* government here!"

None of us had heard of the "Blue Barn in the Ram Yard" until a sympathetic Cambridge policeman suggested that we go there or four luncheon. The genial host who served us a delicious meal in the loft of the "barn" was a retired actor who years ago played in *Way Down East* in American cities; one of our party had seen him in that play in Minneapolis. The blowing of the horn in front of the wakeman's house in Ripon, that city of ancient customs in Yorkshire, was an event to remember. Although more than a million travelers a year go to Czestochowa, Poland, this is not a tourist center, for the travelers are pilgrims—so almost exclusively pilgrims that during our Sunday there we were mistaken for pilgrims, too, who had come all the way from America to worship before the Black Madonna.

Frequent recesses in our hurried schedule gave restful interludes. Walking through the silent mountain forest of Norway spruces at Frognersettern, we could see at an opening the evening lights of Oslo far below. A week-end at quiet Almsee in the Austrian Alps and other placid pauses were welcomed. To mention a few boat trips (aside from those crossing the Irish Sea and the North Sea) there was the ride through the Sognefjord in Norway; the one up the Danube from Wien to Linz; the day at Spreewald where our boat was poled about among some of the 200 islands there; and the pleasant hours on the Königssee in the Bavarian Alps.

The climax of our journey, in height as well as enjoyment of a certain sort, came on the mountain tops of Switzerland—Rigi Kulm, Pilatus Kulm, Jungfraujoch.

It would be impossible, in anything less than a thousand-page report, to give an adequate account of our "long tour." The participants* enthusiastically agree that no one but J. Chester Bradley could have planned and conducted so extensive and varied a trip at so little expense.

Where time permitted, we were glad to find entomological friends in various places. To some of us one of the chief pleasures of the stay in London was the chat with Frederick P. Laing at the British Museum of Natural History. The day four of us spent at the Rothamsted Experimental Station at Harpenden was made delightful by Dr. C. B. Williams and others of the staff. We missed Dr. A. D. Imms at Cambridge but saw him at Berlin. Three of us had a happy day at Lyngby, Denmark, where Dr. and Mrs. Ernest Gram and others welcomed us. It was most pleasant, too, to spend an evening with Dr. and Mrs. Harry Lamont Parker in Paris.

Of course the objective of our trip was the International Congress of Entomology at Berlin. More than 1,100 members, active and associate, were registered there, and the flags of more than forty countries indicated the places from which these guests came. As always at such gatherings, the personal contacts were of even more interest than the best of programs. There were ample opportunities for such enjoyment. We could meet for tea every afternoon, if we so desired, in the garden of the university. In addition to such gatherings, we were feted, without expense to guests, during five evenings. On Monday evening, August 15, Americans attending the Congress, together

* Our "long-tour" party numbered 16 (only four being entomologists) when we sailed from Montreal in June: Ruth S. Baker, J. Chester Bradley, Mary K. Bryan, Esther C. Hendee, Dr. and Mrs. Albert Jonannsen, Dr. and Mrs. Oskar Johannsen, Alpna E. Myers, Edith M. Patch, Adelaide C. Wright, Mrs. Mabel M. Wright and four girls who remained with us only until the close of our London visit—Alice Bull, Anne Bull, Mary Otis Dudley and Florence Ingall. Elisabeth S. Foote, Anne R. Mathews and Mildred Spicer, who left the United States later, joined us at the end of our Wales tour. During our stay in Berlin, Dr. Ralph V. Chamberlin from Salt Lake City, C. F. W. Muesebeck from Washington, D. C., and Curtis W. Sabrosky from Michigan State College were with us. Dr. C. B. Williams and John Deal from the Rothamsted Experimental Station at Harpenden also joined our party at Berlin; and after the Congress session Mr. Deal traveled with us for a month, until we sailed from France.

with certain Americans residing in Germany, were given a friendly reception with buffet at the Karl Schurz House. Following Tuesday afternoon at the Deutschen Entomologischen Institute, where we were guided most delightfully by Dr. Walther Horn, we met for a social hour and supper at Harnackhaus. Wednesday evening the Reichsministers invited the Congress guests to attend a concert, followed by a dinner in the Volksbildung. On Thursday evening we were entertained in the Rathaus by the Chief Burgomaster and City President of Berlin. And on Friday evening we attended the formal banquet, where the place card of each guest had attached a piece of amber containing fossil insects.

SCIENTIFIC NOTES

Further Notes on Cyanide Fumigation of Mushroom Houses

There has recently been placed upon the market a small portable generator for fumigating with hydrocyanic acid gas. In this generator the gas is generated outside the building to be fumigated and forced in by the pressure developed in its generation. The generator offers some improvements over the three other methods used by Davis & Claborn (1935) for fumigating mushroom houses with this gas. It combines the advantages of fumigating with liquid hydrocyanic acid with those of the pot method, in that the operator remains outside the building in the open air and the materials used (sodium cyanide and sulfuric acid) are the cheapest.

During October, 1937, tests were made in several mushroom houses at peak heat to determine the concentrations of gas possible of attainment with the generator. In these tests, in part purposely and in part inadvertently, conditions were made as difficult as possible. In two of the mushroom houses the generator used did not have sufficient capacity and had to be reloaded during fumigation, thus doubling the total time required for generation of the gas. In three houses the delivery end of the hose from the generator was placed just within the door at the end away from the wind, which was blowing at the rate of about 10 miles per hour, and the aspirations were made from the end toward the wind. It is well known that, even in well-sealed houses, gas tends to collect and remain in the end or side away from the wind. In one of these three houses no fans were run during the fumigation, and in only two houses were fans running while the gas was being generated. In the remainder the fans were turned on in from two to several minutes after all the gas had entered the houses. This increased still further the average time required for distribution of the gas. Balanced against these difficulties is the fact that in two houses the delivery hose was run into the central alleyway for about two-thirds the length of the house and withdrawn during generation, giving a more even initial distribution of the gas.

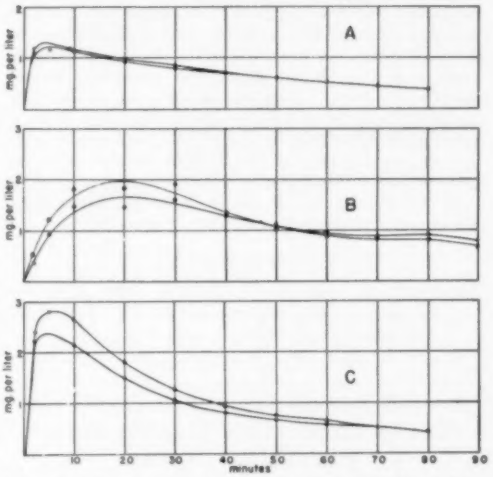

FIG. 1.—Average concentration curves obtained in fumigation of mushroom houses with hydrocyanic acid gas: A, Granular calcium cyanide; B, sodium cyanide in generator; C, sodium cyanide in pots. In each case the upper curve gives the concentration at the top of the house and the lower curve that at the bottom.

Table 1.—Concentrations obtained by three methods of generating hydrocyanic acid gas in mushroom houses.

Method	Concentration of Gas, Mg. per Liter				Minutes Required to Drop to 0.4 Mg. per Liter	
	Maximum		Mean			
	Top	Bottom	Top	Bottom	Top	Bottom
Calcium cyanide, granular	1.26	1.14	0.77	0.74	75	75
Sodium cyanide, generator	1.90	1.59	1.17	1.10	*	*
Sodium cyanide in pots	2.60	2.37	1.18	1.03	88	82

* Concentration above 4 mg. per liter after 100 minutes.

The concentration curves obtained are shown in fig. 1, compared with similar concentration curves previously obtained in the same houses and under approximately the same conditions with granular calcium cyanide and sodium cyanide (1–1½–2) in pots.

In all the tests the ends of the aspirating tubes were 8 to 10 feet inside the house in the central alleyway at the opposite end from the generator, one tube on or very close to the floor and the other tube about 8 inches from the false ceiling.

Conditions in these houses were probably as nearly as ideal as possible at the time of the fumigations with granular calcium cyanide, as the generation of gas was unusually rapid and the peak consequently rather high for this method. The average concentration curve obtained in these houses with the pot method approximates closely the average curve obtained in all houses fumigated by this method.

Table 1 gives the maximum and mean concentrations of the gas figured on exposures for 100 minutes or until the concentration had dropped to 0.4 milligrams per liter. Owing to the much broader peak and the slower drop, the generator shows nearly the same mean concentrations as the pot method, in spite of a lower peak. The slow drop is perhaps attributable to the higher concentration of gas at the lee end of the houses slowly diffusing toward the windward end.—8-29-38.

A. C. DAVIS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

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Resistance of *Stomoxys calcitrans* (L.) to Laboratory Application of Pyrethrum Spray

A series of experiments with stableflies was conducted in a manner simulating Peet-Grady tests of insecticides. In each test about 50 freshly trapped, wild *Stomoxys calcitrans* (L.) were liberated in a concrete vault of 28.5 cubic meters capacity. This is 4.66 times the capacity of a standard Peet-Grady chamber. To produce a mist in the large vault comparable in concentration to the standard Peet-Grady spray, it was necessary to use 55.9 cubic centimeters of Official Control Insecticide (O.C.I. of the National Association of Insecticide and Disinfectant Manufacturers). Spray was produced by a small suction-type hand atomizer. Temperature was uniform at 27 degrees ± 2 degrees C. Humidity was 50 ± 8 per cent. Ten minutes after spraying, paralyzed flies were collected from the floor, placed in a recovery cage and provided with food and water. The vault was ventilated thoroughly before each test. Results are shown in table 1.—9-2-38.

CRAIG EAGLESON, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

Gulf Coast Marsh Ditches That Remain in Good Condition Without Maintenance

During the winter of 1933–34, a pest mosquito control project was operated on the Mississippi coast and adjacent islands under the supervision of the Bureau of Entomology and Plant Quarantine with the writers in charge of the work. Funds were provided by the Civil Works Administration. About 135 miles of ditches were cut before the project was abruptly terminated on February 15, 1934. Most of the ditches were in marshes and were cut about 20 inches wide with vertical sides, and sufficiently deep to allow free movement of the tides. These ditches were spaced from 100 to 200 feet apart. Some ditches were also cut in sand, especially those on the islands, and were wide with sloping sides. A few large ditches in marshes were constructed with dynamite.

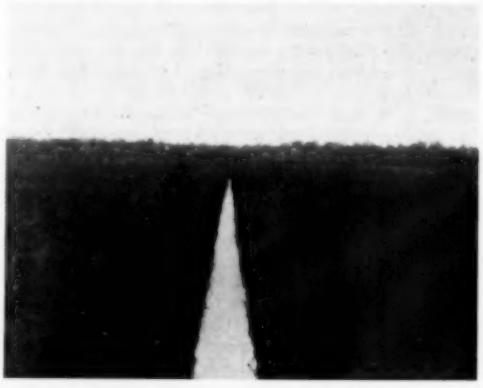

FIG. 1.—Mosquito control ditch in practically perfect condition four years after construction. No maintenance program was carried on here.

Table 1.—Results of tests of resistance of *Stomoxys calcitrans* (L.) and *Musca domestica* L. to pyrethrum and kerosene sprays.

SPECIES	DOSE*	FRACTION OF THE M.L.D. FOR *Musca domestica* L.	RESULTS
S. calcitrans	5.60 cc. OCI	1/10	100% initial torpor, 100% mortality
S. calcitrans	2.80 cc. OCI	1/20	100% initial torpor, 100% mortality
S. calcitrans	1.12 cc. OCI	1/50	97% initial torpor, 100% mortality
S. calcitrans	0.56 cc. OCI	1/100	<75% initial torpor, 93% mortality
S. calcitrans	0.56 cc. OCI + 9.44 cc. refined kerosene†	1/100	<75% initial torpor, 88% mortality
S. calcitrans	5.60 cc. refined kerosene	—	10% disabled in 10 minutes
M. domestica	55.90 cc. OCI	1/1	98% initial torpor, 51% mortality

* One test at each strength; 434 *Stomoxys calcitrans* used. Mortality was observed the day following application.

† A petroleum distillate with an initial boiling point above 150 degrees C. and end point not above 277 degrees C., A.P.I. gravity 38 to 43, Saybolt color 25 plus, odor none.

Before the ditching, the marshes could be crossed only with hip boots, and mosquitoes swarmed everywhere. A few months after the project closed, a careful survey showed that the marshes were relatively dry and that no mosquitoes were breeding.

No other funds have been allotted to continue this work or provide for the maintenance of the ditches constructed at that time. Examinations made during the past few months—more than four years after the construction of the ditches—revealed that there has been practically no deterioration in most of the marsh ditches, fig. 1, and that they have effectively prevented mosquito breeding. The marshes are practically dry and can easily be crossed without boots or overshoes. Minnows are swarming in the ditches, and there are no pools of surface water. About the only ditches which show any evidence of damage are those where cattle have been running at large and have broken in the sides.

The sand ditches are also in almost perfect condition, and, except in a very few places where vegetation is growing in the bottom, they are functioning better than when first constructed.

The fact that this mosquito control system can be maintained at almost no cost if livestock is prevented from running at large over the marshes should encourage Gulf Coast cities to continue the work already begun.—9-8-38.

CLAY LYLE, *Mississippi State College, State College,* and H. GLADNEY, *Mississippi Plant Board, Ocean Springs.*

Spontaneous Heating of Insect Baits

To determine the spontaneous heating of prepared grasshopper baits, a wooden box was used measuring

FIG. 1.—Potentiometer and thermocouples used in measuring spontaneous heat.

34.5×41.5×36.0 inches, and holding 700 pounds of oil bait and 840 pounds of wet bait. Baits were prepared and tamped tight with 12 thermocouples arranged at critical points, fig. 1. Temperature readings made on a potentiometer were continued until distinct losses in heat were noted, fig. 2. Practically no heating occurred in the bait containing mineral oil. However, considerable heating occurred in the oil bait after water, 5 per cent by weight, was poured into the mass. Heating occurred in all baits containing water. The maximum temperature reached was 119 degrees F. Heating was

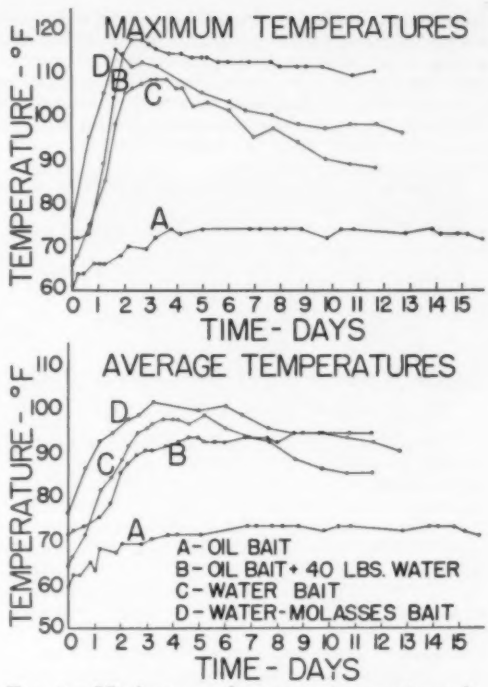

FIG. 2.—Maximum and average temperatures in heating bait: A, bran 50 pounds, ground corn cobs 50 pounds, dry sodium arsenite 3 pounds, S.A.E. 30 lubricating oil 2 gallons; B, bait A with 5 per cent by weight of water added slowly at a single point; C, bran 50 pounds, ground corn cobs 50 pounds, crude white arsenic 4 pounds, water 8 gallons; D, bran 50 pounds, ground corn cobs 50 pounds, crude white arsenic 4 pounds, black strap molasses 2 quarts, water 8 gallons.

followed by a gradual loss in temperature with the bait undergoing an ensilar process that produced very little heat. Molding occurred where air came in contact with the bait.—9-7-38.

M. D. FARRAR, *Illinois Natural History Survey,* and R. H. REED, *University of Illinois, Urbana.*

Flight of *Alabama argillacea* (Hbn.)

A great flight of *Alabama argillacea* (Hbn.), was noted at Sioux City, Iowa, the night of September 15, 1938. Temperature was low, about 55 degrees, but the moths appeared on store fronts in large numbers and were a decided nuisance on the streets. They had not been previously observed this season. —9-19-38.

C. N. AINSLIE, *Sioux City, Iowa.*

Egg Predator of the Chinch Bug

While carrying on some experiments with the chinch bug, *Blissus leucopterus* (Say), during the summer of 1938, the writer noticed that a beetle, *Collops quadrimaculatus* F. was usually found where chinch bugs were abundant. The beetles appeared to be feeding on chinch bug eggs, and they were very numerous, averaging about one to each sorghum plant. Several of these beetles were col-

lected and brought into the laboratory and were fed exclusively on chinch bug eggs. Six beetles ate 1,404 eggs in a period of 10 days, an average of about 23 eggs per day for each beetle. The beetles appeared to be satisfied with their diet after feeding on chinch bug eggs for more than two weeks, but under no conditions could they be induced to feed upon nymphs or adult chinch bugs.

A female chinch bug under field conditions will lay between four and five eggs per day; at this rate one of these beetles could consume about as many eggs as five female chinch bugs lay.—9-21-38.

R. G. DAHMS and MARTIN KAGAN, *Oklahoma Agricultural Experiment Station, Stillwater.*

Some New and Little Known Aphididae of California

A careful study of any group of insects in a given locality always brings to light new and interesting information. While it is desirable to collect all of this information together in a monographic publication, it is often desirable to make available from time to time certain facts which should not be obscured during the long interval necessary to complete a comprehensive report. In the study of the Aphididae of California there are certain new and more nearly complete records, aside from the descriptions of new species, which might be published from time to time. A number of species either new to the state or which are not well known to entomologists at large are included in this paper.

Amphicercidus flocculosa (G. & P.). On snowberry or waxberry, *Symphoricarpos rotundifolius* Gray, at Big Bear Lake, San Bernardino County, November 10, 1937. Sexual females and eggs also present.

The celery aphid, *Aphis apii* Theob., on celery, wild carrot and other umbelliferous plants in southern and middle California, by H. H. P. Severin and J. H. Freitag, 1935.

The strawberry root aphid, *Aphis forbesi* Weed, on strawberry at San José, 1928, and in greenhouse at Berkeley. Specimens have so far been observed only on the foliage of the plants.

The nine-bark aphid, *Aphis neilliae* Oest., on nine-bark, *Physocarpus capitatus* (Pursh), in Lake County by P. S. Lange, July 13, 1935.

The New Mexican aphid, *Aphis neomexicana* (Ckll.), on *Ribes*, St. Helena, June 25, 1931, by P. S. Bartholomew.

The sedum aphid, *Aphis sedi* Kalt., abundant on *Sedum*, *Echeveria*, *Cotyledon* and other succulents at Berkeley and other places in middle California, 1935. A small very dark green species often determined as *Aphis gossypii* Glover. My specimens agree with those collected in Belgium close to the original type locality.

Capitophorus patonkus H. & F. on *Artemisia vulgaris* Linn. at Berkeley, 1935. Abundant on the leaves of only a few plants.

The polygonum aphid, *Capitophorus gillettei* Theob. (*Rhopalosiphum hippophaes* Koch of Gillette, JOUR. ECON. ENT. **8**: 375, 1915), on alpine knotweed, *Polygonum alpinum* All., in the Echo Lakes region, Eldorado County, 1937.

The raspberry aphid, *Cerosipha rubifolii* (Thos.), on raspberry, Palo Alto, by L. M. Smith, 1928.

Chaitophorus pusillus H. & F. on willow, Berkeley, 1935. Abundant and producing quantities of honeydew and black smut fungus. Sexes present.

Cinara brevispinosa (G. & P.) on lodgepole pine, Echo Lakes region, Eldorado County, 1937.

Cinara edulis (Wil.) on Piñon, *Pinus edulis* Engl., Lone Pine, 1937.

Cinara engelmanniensis (G. & P.) on Sitka spruce, *Picea sitchensis* (Bongard), Bayside, 1935.

Cinara murrayanae (G. & P.) on whitebark pine, *Pinus albicaulis* Engl., Mt. Ralston, Echo Lakes region, Eldorado Co., 1937.

Wild currant aphid, *Kakimia cynosbati* (Oest.), on wild black currant, Yosemite, May and June, 1938. Curling the terminal leaves and very abundant.

Macrosiphum atripes G. & P. on California goldenrod, Echo Lakes region, Eldorado Co., 1937.

The western fern aphid, *Macrosiphum pteridis* Wils., on bracken, sword fern and other ferns. Common along the Pacific Coast of North America, but only recently collected in southern California in the San Bernandino Mountains by R. H. Smith, 1937.

The rose leaf aphid, *Macrosiphum rosæfolium* Theob., on cultivated roses at Stanford University, 1931, 1933, and at Merced, 1932, by P. S. Bartholomew. Originally described from Egypt and characterized by the peculiar form of the slightly swollen apices of the cornicles.

The onion aphid, *Micromyzus formosanus* (Tak.) (*Micromyzus alliumcepa* Essig. Pan-Pac. Ent. **11**: 157–60, 1935; **12**: 72, 1936). A shiny reddish-black species often abundant on the foliage of leeks and onions. Also on the bulbs in storage. Middle California, 1927, 1935.

The costal pecan aphid, *Monellia costalis* (Fitch), on *Juglans*, Los Angeles, June 2, 1930, and San Fernando, October 20, 1930, by P. S. Bartholomew. On pecan, San José, September 20, 1935, by L. M. Smith; Pomona, October 5, 1935, by B. J. Hall; Orange County, August 19, 1938, by F. C. Balkam (transmitted by H. H. Keifer).

The elegant aphid, *Myzocallis elegans* (Koch), a small, yellow, clouded-winged species on the leaves of elm at Sacramento, June 12, 1930, by P. S. Bartholomew and at Alturus, July 14, 1935, by W. H. Lange.

The crapemyrtle aphid, *Myzocallis kahawaluokalani* Kirk., on a single plant of crapemyrtle, *Laegerstroemia indica*, at Visalia, May 16, 1937, by F. T. Scott (transmitted by H. H. Keifer). This species was described from Honolulu, Hawaii, by Kirkaldy in 1907 (Proc. Hawaiian Ent. Soc. **1**: 101, 206, 1907). I have mounted slides of specimens collected on crapemyrtle at Gainesville, Fla., September 7, 1928, by A. N. Tissot; at Wiggins, Miss., May 18, 1930, by A. Kislanko; Allendale, S. C., June 8, 1931, by A. Lutkin; and Raleigh, N. C., May 9, 1936, by C. S. Brimley (transmitted by M. D. Leonard). During the past summer Mr. Scott has sent me a few more specimens from Visalia.

The morning-glory aphid, *Myzus convolvuli* (Kalt.), has generally been reported in this country as the foxglove aphid, *M. pseudosolani* Theob. It is common in much of the coastal area of middle and northern California as well as in Oregon. *Macrosiphum aucubae* Barth. appears to be a synonym.

The ornate aphid, *Myzus ornatus* Laing, is found on a variety of plants in the San Francisco Bay region and was also found in Los Angeles in 1937 (Pan-Pacific Ent. **14**: 92–5, 1938). It is a common species in England and Belgium, but has not been reported in North America outside of California.

The sedge aphid, *Yezabura eriophori* (Walk.) (*Aphis, Ceruraphis, Rhopalosiphum*), was first taken on *Cyperus virens* Michx. in Berkeley, November 1, 1937. The mature forms are very dark or black with a conspicuous white tuft of fluffy wax at the posterior end. I also took this aphid in England and Belgium, but have seen no other record of its occurrence in North America. *Aphis viburnicola* Gill., regarded as a synonym by some authors, is certainly not this species, although there are some close resemblances. The presence of circular sensoria on antennal segment III of the apterae at once distinguishes the sedge aphid.—9-19-38.

E. O. ESSIG, *University of California, Berkeley.*

A Method of Rearing the Bedbug, *Cimex lectularius* L., for Studies in Toxicology and Medical Entomology

The use of the bedbug, *Cimex lectularius* L., as a test insect for studies in toxicology or medical entomology has been neglected due to the difficulties in rearing. By the method explained below bedbugs are reared in large numbers in a minimum of time with very low mortality, and all stages are provided for study. Only one full meal is required to induce molting in the bedbug. Therefore, if feeding dates are recorded, the exact instar of the bugs is known.

Adults are kept in a Petri dish with two circular pieces of paper toweling which serve to absorb excrement and afford a place for the attachment of eggs. Every fifth day adults are removed from the Petri dish (by means of an aspirator attached to a vacuum line), fed and placed in another Petri dish with clean paper. The old paper laden with eggs remains in the dish, allowing the eggs to hatch in about six days. The nymphs are removed with a brush and fed, then placed in 1.7×6.5 centimeter shell vials fitted with a short strip of paper toweling. The vials are plugged with cotton, numbered and stacked in a beaker or dish. The bedbugs are kept at a constant temperature of 75 to 85 degrees F. and 60 to 65 per cent relative humidity.

Guinea pigs are used as a source of food supply for the bugs. In order to use this animal a device had to be constructed which is capable of holding the animal in such a manner that the bug may be allowed to feed conveniently upon the shaven abdomen of the guinea pig. This device, Fig. 1 consists of a heavy baseboard slightly shorter than and as wide as the animal. At one end is a high back and on each side is a board fitted with a slot to hold a removable sheet of metal. This sheet prevents the animal from gnawing at the vial containing the bedbugs. The guinea pig is fastened by placing it on its haunches between the side boards and securing a strap across the chest under the fore legs and around the board at the back. The animal is adjusted so that the abdomen is between the side boards. The strap is tightened moderately and the hind legs are bound by another strap. A pan made from a pie tin serves to catch urine and feces. The vial or beaker containing the bedbugs is held on the abdomen by a rubber band stretched between the side boards.

Adults are fed by placing them in a 30 cubic centimeter beaker, which is then covered with a fine Batiste cloth and inverted on the abdomen of the guinea pig, thus enabling the bugs to feed on the guinea pig by inserting their mouth parts through the cloth. To feed nymphs, the strip of paper is removed from the rearing vial with forceps and the nymphs are brushed from it into a second vial containing a small square of stiff paper. This second vial is inverted on the guinea pig, and the bugs are allowed to crawl down the paper and feed directly upon the animal. When the bugs are fully engorged they crawl back up the paper. The vial is tipped and by slow manipulation is removed, all the nymphs being retained. The nymphs are transferred back to the rearing vial fitted with a clean strip of paper. It is possible to feed about 75 adults, 100 newly hatched nymphs or 25 nymphs of later instars in one operation.—10-8-38.

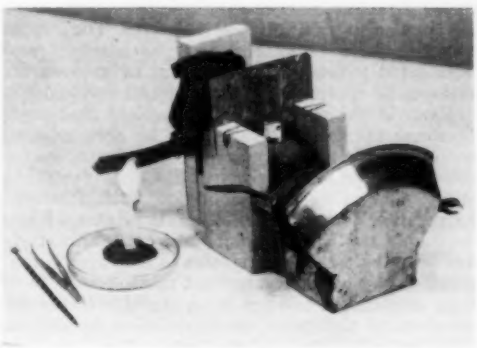

FIG. 1.—This illustrates the device for holding the guinea pig, and shows the bedbugs feeding on the abdomen of the animal. A rearing vial stands in a Petri dish ready to receive the fed bedbugs.

R. C. RENDTORFF, *Illinois State Natural History Survey and Agricultural Experiment Station, Urbana.*

Dinitro-O-Cyclohexylphenol in the Control of the Citrus Red Mite

In 1936, Boyce & Prendergast (1936) reported promising results in the control of the citrus red mite, *Paratetranychus citri* McG., through the use of dinitro-o-cyclohexylphenol applied as a dust. This dust was prepared by atomizing an oil solution of the dinitro-phenol compound on to diatomaceous earth. Subsequent studies have shown that when dinitro-o-cyclohexylphenol is incorporated with such alkaline diluents as diatomaceous earth, talc and lime, the compound reacts with certain of the components of the diluent, with a resultant formation of salts. These salts or phenates are less effective than the parent compound in the control of the citrus red mite. Consequently, a search was made for diluents that do not react with dinitro-o-cyclohexylphenol and it was found that lignocellulosic materials are in general very satisfactory in this regard. From the standpoint of general properties and commercial availability, walnut shell flour and redwood bark flour appear most promising at present.

Satisfactory mixtures of these diluents with dinitro-o-cyclohexylphenol may be prepared by mechanical mixing in a ball mill. However, more homogenous mixtures are obtained by dissolving the dinitro-phenol compound in a volatile solvent

which is then atomized on to the diluent. A mixture of toluene and carbon tetrachloride is a satisfactory solvent. Dust preparations containing approximately 1 per cent of the toxicant have been found to be most practical in field use.

During the 1937 season our laboratory prepared and applied approximately 60,000 pounds of this dust mixture in connection with experimental work on the control of the citrus red mite. The results obtained were in general very satisfactory and stimulated a demand on the part of growers for commercial quantities of the material during 1938.

Early in the work it became evident that more thorough application than could be accomplished with available dusting equipment was essential for satisfactory results in control. Consequently, a study of dusting equipment was undertaken in cooperation with the Division of Agricultural Engineering of the University of California. This study has resulted in the development of improved equipment. Many of these improved dusting units have been constructed and are being operated in the application of this new insecticidal dust as well as other dusts that are used on citrus.

In order to determine its further merits and limitations, a limited amount of dinitro-o-cyclohexylphenol dust was made available commercially this season under the trade name of *DN Dust* for use on citrus under closely controlled and supervised conditions. During the past six months approximately 700,000 pounds have been applied in treating about 7,000 acres of citrus. The results obtained in control of the citrus red mite have been generally satisfactory, and no commercial injury has occurred.

This dust mixture has also afforded satisfactory control of the six-spotted mite, *Tetranychus sexmaculatus* Riley, on citrus and of the common red spider, *Tetranychus telarius* (L.) and the brown, clover or almond mite, *Bryobia praetiosa* Koch, on Persian walnuts and peaches. The work on citrus and walnuts has been extensive, whereas that on peaches has been very limited.

A report of our studies with dinitro-o-cyclohexylphenol used in dusts and sprays against several species of insects and mites during the past three years is being prepared for publication.—10-26-38.

A. M. BOYCE, *University of California Citrus Experiment Station, Riverside.*

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The Health of Shade Trees

GETTING back to causes and securing control by elimination of conditions favorable to insect multiplication has numerous applications in the economic entomology of shade trees. The life cycle of the shade tree is an extended one, and an acceptable program must recognize this. It is frequently possible to prevent attack by maintaining vigor.

Such conditions were to be found among shade tree insects in the early part of this century that thousands of ornamental white birch in New York state were killed by the bronzed birch borer. It was recognized in a general way that the attacks followed droughts. It was not until later that repeated trials demonstrated the possibilities of protecting such trees by feeding and thus offsetting to a large extent drought injury. The writer has in mind one striking case of 64 ornamental white birch set some 40 years ago in four rows of 16 trees each; about 10 years ago nearly half of these had been killed by the combined effects of drought, starvation and bronzed birch borer infestation. All these birch have subsequently died. All could have been thriving and vigorous today if there had been systematic feeding in order to raise to normal the resistance of the trees to invasion by the borer.

It seems a far cry to associate earlier elm leaf beetle injury with the sweeping destruction September last in New England of 1,000,000 or more large shade trees. A large proportion of these trees were elms, though the percentage destroyed was not markedly greater than in the case of other favorite shade trees. It is not claimed that the elm leaf beetle was the only cause weakening trees to such an extent that the root system was unable to support the trees in the fury of the storm. It was, however, an important factor since it is impossible to develop a good root system on trees which are repeatedly defoliated. It is the writer's belief that repeated strippings by elm leaf beetle, canker worms, gypsy moth or other insects in the storm devastated area were material factors in weakening the trees. Severe wind storms are occasional throughout much of the United States, and the shade tree wreckage of last September suggests the need of eliminating so far as possible factors which weaken shade trees.

It is not enough to ascertain the immediate and direct effects of insect attack. The indirect may be decidedly more important. It is our opinion that the financial losses inflicted by the hurricane on the utility companies may greatly exceed those caused by the destruction and removal of the trees, great though these are. The interruptions, caused by the blowing down of trees, in telephone, electric light and power services were serious to millions of patrons, some being without these modern necessities several days or weeks. The cost of rehabilitation and the loss of income by the utility companies during the period of suspended service make an enormous total. All of this cost is eventually met by patrons and indirectly affects all people in the devastated area. It is a problem in which the entomologist with the broader outlook can render a material service. The schedule for the fruit orchard is planned for 30 to 50 years. A schedule for an even longer period should be the goal for shade trees.

The hurricane or wind storm may have an effect on local insect attack. The destruction by the storm of 30 or 40 per cent of the elms in a small area will probably result in an increased infestation by the elm leaf beetle, since there are now more beetles per tree hibernating in nearby buildings. The same condition is likely to occur in areas where the Japanese beetle is prevalent, since the storm would hardly affect the grubs. The large number of elm branches or trees weakened by the storm is attractive to the European elm bark beetle. The probabilities favor many elm logs and stumps being left where the

beetles will find them in the spring. Next year and possibly for several years these beetles will be more than ever active as carriers of the Dutch elm disease. It is probable that the extensive tracts of downed timber, especially pine, will produce great numbers of bark beetles and long-horned beetles, *Monochamus*, and these in turn may attack trees which under other conditions would not become infested. There is likely to be a considerable increase in the numbers of Buprestids and a rapid killing of weakened trees.

The hurricane has presented novel shade tree problems in New England and provided strong arguments for growing stronger trees with the ability more successfully to resist insect attack as well as the fury of wind storm.

E. P. FELT

BOOK REVIEWS

Nematodes Parasitic in Animals, by Geoffrey Lapage. 1938. 163 pp. Chemical Publishing Co. of N. Y., Inc., New York. $1.75.

This little handbook presents a thought-stimulating review of our present knowledge of the nematodes parasitic on animals. Many authors endeavor to present their material in such a way as to impress the casual reader with the completeness of the knowledge available on the subject. In this work, however, Dr. Lapage does just the reverse. He brings out on almost every page the lack of facts and the need for more definite and conclusive information. Thus this publication will prove especially helpful to young investigators who have not had an opportunity to learn where important gaps in factual matter exist.

Chapter 1 deals briefly with the structure, life history and classification of the nematodes, and Chapter 2 with their physiology. The author indicates his views as to the importance of physiological work on the parasitic nematodes by devoting 69 pages (50 per cent of the text) to this topic and by his statement: "One of the main reasons for this failure (to find effective methods of control) must surely be our almost complete lack of reliable knowledge of the physiology of these parasites. We know next to nothing about the factors which determine the success of their parasitic life, so that efforts to make that life impossible are without a rational basis." Chapter 3 contains an informative review of the resistance of the host to nematode attack. The matter in this chapter should be of distinct interest to those entomologists who are working with insects parasitic on higher animals. Chapter 4 deals briefly with control under the captions "Control by Farming Methods" (related to the study of resistance and breeding), "Control by Disturbance of the Normal Physiology of the Parasites," "Control by Anthelmintics" and "Control by Maintaining the Resistance or Tolerance of the Host." In commenting on the last subject the author points out that there will be little advance in the control of parasitic nematodes until a better understanding is obtained of their relationship with their host and says, "It is to the biologist, therefore, and to those who train him, that all must look who wish to mitigate the suffering inflicted on man and animals by the parasitic nematode."

Since Dr. Lapage's review is not of a critical nature, he has presented certain statements of various authors which are incorrect. The numerous references in the text to the excellent bibliography included in the work (404 titles) will, however, enable the reader to refer to original works to get more nearly complete information on a given subject or to verify any points in doubt. The author's brief review of the literature, together with the excellent bibliography, will make the handbook very useful to teachers.—9-13-38.

F. C. BISHOPP, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine, Washington, D. C.*

Der Kornkäfer (*Calandra granaria* L.) Biologie und Bekampfung, by K. T. Anderson. 1938. 108 pp. 36 figs., 1 pl. Paul Parey, Berlin, Rm. 6.50.

This work as the title indicates is a study of the biology and control of the granary weevil, *Calandra granaria* (L.).

It is divided into four parts. The first part is a thorough description of the beetle and its life stages and a consideration of the size and weight of the insect as influenced by such environmental factors as type of food, temperature and moisture. The second part treats of the insect's biology and physiology and includes discussions of length of life, reproduction and development as influenced by various factors. The third part is an ecological consideration of such points as distribution, length of development, number of generations, enemies and mortality.

The final division of the work is concerned with control. A rather complete discussion of all types of control is given, including physical and chemical means. Under the latter will be found mention of many of the newer fumigants and a discussion of vacuum fumigation. The work is a good bringing together of our knowledge of this important grain pest and its methods of control. There is a bibliography of 84 titles.—10-4-38.

WILLIAM P. HAYES, *University of Illinois, Urbana.*

Insects of Citrus and Other Subtropical Fruits, by Henry J. Quayle. 1938. ix+583 pp., 377 figs. Comstock Publishing Co., Inc., Ithaca, N. Y. $5.00.

Entomologists concerned with citrus fruit insects have long been at a disadvantage from lack of an adequate, comprehensive and authoritative treatise on this group. When the writer first became interested in this field, insect publications for California were largely confined to scattered state, university and federal reports, most important of which was Comstock's (1880) *Report on Scale Insects.* In

Florida, Hubbard's *Insects Affecting the Orange Tree* (1885) was a useful treatise at the time published, but very inadequate at the beginning of the twentieth century. Citrus literature for other parts of the world was even more fragmentary than in this country. The first really authoritative and truly helpful treatise for California workers was Quayle's University of California Bulletin **214** (1911), *Citrus Fruit Insects*, supplemented by bulletins **222**, **223** and **226**. These presented a reasonably complete description of the more important citrus insects and mites prevalent in California. Subsequent workers in Florida and other parts of the world have issued bulletins summarizing this field for their respective countries. However, outside of these respective summaries, a large, important and widely scattered literature on subtropical pests and control practices has been built up. To the average citrus worker or adviser, much of this literature has not been available.

The recent issuance of Quayle's *Insects of Citrus and Other Subtropical Fruits* furnishes a large audience the long desired book which brings together this widely scattered information. Furthermore, this book rises above the status of general compilation so characteristic of many insect texts, as it is the work of an authority who pours into its pages the results of 30 years of continuous study and experimentation in both laboratory and field, including three years in the more important foreign citrus fruit producing countries.

The scope of this work is world wide, although naturally special prominence is given to those species prevalent in this country. The author states, "The list of citrus fruit insects is as complete as it has been possible to make it for all the more important citrus fruit sections of the world. The list of insects of the avocado has also been made as complete as possible for the world. The important insects of other subtropical fruits, particularly in the United States, likewise are included."

The opening chapter gives a brief discussion of the 12 different fruits included, lists their important pests in California, and, in the case of citrus, includes a key to the principal citrus fruit insects and mites in the United States. The two succeeding chapters cover the major insects and mites that attack citrus fruits, as well as their natural enemies. These are followed by a complete list of predacious and parasitic insects that attack citrus and other subtropical pests. A chapter on minor insects of citrus extends the total pages devoted to pests of this fruit crop to 330. One short chapter is devoted to rodents, nematodes and snails. Control work is presented in separate chapters under fumigating; also spraying and dusting combined. The final chapter is on domestic plant quarantine.

This book has been so well prepared by an expert and has been so carefully edited by the author's co-workers that there is little opening for criticism. In general, the major citrus pests are adequately discussed, special prominence being given to the group Coccidae, or scale insects. In most parts of the world scale insects are the most destructive citrus pests against which major control efforts are centered, in California upwards of three-fourths of the four or five million dollars expended annually being directed against this group. Especially complete is the discussion of the California red scale, the world's most important citrus pest, and means of distinguishing it from the yellow and other closely related species. A special feature not noted in other textbooks is the inclusion of numerous pygidial drawings. These characters are important in distinguishing scales microscopically and should prove helpful to coccidologists. However, in a textbook for general use doubt might well be expressed as to their value compared to good photographs of scales *in situ*, which they appear to have displaced to too great an extent.

The arrangement throughout appears to follow the usual sequence by orders, families and species. Such an arrangement, while entomologically correct, shuffles those of lesser importance and those less frequently met in the same field with those of outstanding importance. For instance, by this arrangement one has to wade through 70 pages of lesser important species in chapters two and three before reaching the predominatingly important California red scale. A large number of pests, such as the green citrus aphid, the orange chionaspis, the chaff scale and the West Indian peach scale might well have been more adequately described and better illustrated. Of course, there is a limit to photographs in a five-dollar book. The natural enemies in the subtropical field are given particular attention, fully one-fourth of the text under major citrus pests being devoted to this group with splendid illustrations.

The pests of subtropical fruits other than citrus included in this book comprise mainly the more outstanding species found in the United States, especially California. A synoptical table of included species is presented at the beginning of each crop which includes the avocado, grape, Persian walnut, almond, pecan, fig, olive, date, Oriental persimmon, pomegranate and sweet cherry. The restricted discussion of pests of these particular crops is exemplified by the fact that less than 100 pages are devoted to these 11 different groups of insect pests as compared to more than 300 devoted to citrus.

In the field of control, the chapter on fumigation is very comprehensive. The history and development of fumigation are presented in some detail. Discussion is given of factors affecting efficiency and tree injury. On controversial subjects as humidity, temperature and soil moisture, there might be some disagreement with the conclusions in the text, but, as a whole, the author has handled these subjects exceedingly well. Perhaps the greatest criticism concerns dosage which is fundamental to orchard fumigation. This subject merited fuller and clearer discussion than given. For 30 years practically all fumigation in California has followed two definite dosage charts; the first, used for pot and machine generation, 1908 to 1919, and the second, for liquid gas, from 1919 (with revision in 1920) to date. The first schedule is entirely omitted and the second schedule should have been given in the standard form as issued, and always carried by fumigation outfits. This later revised schedule issued by the U. S. Bureau of Entomology in 1920 (not 1930 as stated) has undergone no change in the last 18 years. It would have been helpful for foreign fumigators to have included dosage schedules in metric measurements as used in foreign countries. The inclusion of methods of determination of HCN concentration by sampling will be welcomed by many workers in this field. Control recommendations for the various citrus pests are given and by their variety show the complexity of the problem where resistant and non-resistant types are found.

A chapter on spraying and dusting, largely devoted to petroleum oils and sulfur, presents the important features of these practices.

This book, *Insects of Citrus and Other Subtropical Fruits*, is of very usable size, well printed on good paper, and carries illustrations of a high degree of excellence. A splendid feature certain to be welcomed by the reader is the ample footnote references on the same page as the subject. We heartily recommend this authentic, comprehensive and well-prepared book to all interested in the citrus and subtropical field whether investigator, practicing entomologist or grower.—11-7-38.

R. S. WOGLUM, *California Fruit Growers Exchange, Los Angeles.*

CURRENT NOTES

COMMEMORATIVE MEETING AT AMHERST

Sixty-five alumni, staff members and friends of the Department of Entomology, Massachusetts State College, met at Amherst, September 30, 1938, to install a bronze plaque commemorating the small wooden building that was the original home of economic entomology at the Massachusetts Agricultural College.

This building, proposed in 1889 and erected in 1890, served as the chief entomological laboratory on the campus for many years. During this period many noteworthy entomologists received their training at the Massachusetts Agricultural College. Among these are A. F. Burgess, E. P. Felt, J. B. Knight, C. P. Lounsbury, H. A. Ballou, R. A. Cooley and W. E. Hinds.

Present at the meeting were Dr. Felt, Mr. Burgess and Dr. H. T. Fernald, who was head of the Department of Entomology from 1899 to 1930. All three gave interesting talks, according to C. P. Alexander, present head of the Department of Entomology and Zoology at the College. Dr. Felt presented the plaque to the College. Acceptance was made by President Hugh P. Baker on behalf of the institution. At the afternoon meetings a discussion of the work and activities of the Department of Entomology was held.

PROGRAM OF ROCKY MOUNTAIN CONFERENCE OF ENTOMOLOGISTS

Papers presented before the fourteenth annual Rocky Mountain Conference of Entomologists at the University of Wyoming summer camp, Centennial, Wyo., August 14–19, are as follows:

An Outbreak of the Walnut *Datana*, 1935–38 ..... Ephraim Hixson

Symposium:

The Building of Insect Collections Representative of the Intermountain Region. Leaders: Robert Potts, Vasco M. Tanner, Maurice T. James, Don B. Whelan, Roger C. Smith.

Preserving Insect Specimens and Preparing Material for Display ..... R. L. Post

The Celery Stalkworm, *Nemaphila noctuella* ..... Roger C. Smith

Grasshopper Control Studies ... Roger C. Smith

The Castor Bean in Relation to Insects ..... Roger C. Smith

Symposium:

The 1938 Grasshopper Program. C. L. Corkins. Discussed by T. R. Robb, Gordon Mickle, Ed Beals, Fred R. Lewis, Fred Biederman, Fred H. Kropf and T. R Hupper.

The Striped Cucumber Beetle on Squash and Melons ..... J. L. Hoerner

Results in the Control of the Squash Bug ..... J. L. Hoerner

Biology and Control of the Strawberry Leaf Roller, *Ancylis comptana* (Froel.). R. L. Parker

Effect of Fumigation on Tomato Fruit ..... C. R. Jones

The Wheat White Grub, *Phyllophaga lanceolata* ..... E. G. Kelly

Summer Temperatures and the Tomato Psyllid, *Paratrioza cockerelli* (Sulc.). George M. List

Insect Control on Truck Crops in Northern Illinois ..... L. H. Shropshire

Insect Problems in Wyoming ..... Margaret Greenwalt

Some Work of the Nebraska Station ..... Don B. Whelan

Statistical Methods in Entomology ..... F. M. Wadley

Aphid Studies With a Report on Several New Species ..... Miriam A. Palmer

The General Research Program at the Intermountain Bee Laboratory, U. S. Bureau of Entomology and Plant Quarantine, Laramie, Wyo. ..... A. W. Woodrow

Bacteriological Work at the Intermountain Bee Laboratory, Laramie, Wyo. Herbert J. Stoles

Some Problems Being Studied at the Forest Insect Laboratory of the U. S. Bureau of Entomology and Plant Quarantine, Fort Collins, Colo. ..... W. D. Wygant

Insect Photography for Class Room Use ..... Paul Knight

Resistance of Strains of Bees to American Foul Brood ..... A. P. Sturtevant

Queen Supersedure ..... C. L. Farrar

The following resolutions of general interest were adopted:

Resolved, that studies of upper air currents and their connection with insect migrations would be desirable for this region.

Resolved, that we favor wider interchange of specimens and information to foster the building up of insect collections and museum facilities in the Rocky Mountain region.

Resolved, that we do not favor incorporation as a branch of the American Association of Economic Entomologists since this Conference is not strictly regional in its attendance, and since such incorporation might tend toward standardization and formality.

It was voted to feature discussions on forest and shade tree pests as a part of the 1939 program, and to consider the possibility of arranging a trip into the surrounding national forests to observe insect research and control programs.

Officers elected for 1939 were: C. P. Gillette, Chairman; Vasco M. Tanner, Vice-Chairman; George M. List, Secretary; and C. R. Jones, Treasurer.

ROCKY MOUNTAIN LABORATORY

Funds in the amount of $622,000 have been made available for new buildings and facilities at the Rocky Mountain Laboratory of the United States Public Health Service, Hamilton, Mont. This laboratory is the western branch of the National Institute of Health.

There are at present three buildings. When the new project is completed, this number will have been increased to seven, which will include a large laboratory building for bacteriology, virus diseases, pathology and chemistry, a building for entomology and parasitology, two buildings for rearing laboratory animals and for stock animals, an administration building, a service building for supplies, shops and biological engineering, and a central power and heating plant.

The floor space will be increased two and two-thirds times, and the present staff of 60 will be increased to 120.

The Rocky Mountain Laboratory was originally established for the study of Rocky Mountain spotted fever, but the scope of its work has greatly expanded until its present function may be said to concern the field of diseases of the native fauna transmissible to man. With increased facilities, the scope of the work will be still further expanded and it is expected eventually that it will be to the West in public health research what its parent institution, the National Institute of Health, is to the East.

The present staff includes five entomologists: Dr. R. R. Parker, Director; Dr. R. A. Cooley and Glen M. Kohls, specialists on Ixodoidea; Dr. Cornelius B. Philip, specialist on Culicidae and other biting flies; and William L. Jellison, specialist on Siphonaptera.

NEW PLAN FOR ISSUANCE OF BIOLOGICAL ABSTRACTS

A prime objective in the initiation and development of *Biological Abstracts* related to its important role in integrating the findings of science in an age where specialization is the watchword. In spite of this obvious and generally desirable goal there has been in some quarters a demand for a printing of *Biological Abstracts* in separate parts so that opportunity is afforded scientists so desiring to subscribe to the group of subjects in which they, individually, are most interested. Many reasons for this viewpoint have been offered, chief of which is an assumed reduction in cost for a part as compared with the whole.

The Board of Trustees of *Biological Abstracts* announces that to meet the situation satisfactorily, a plan has been evolved whereby the publication, while continuing to appear as a single entity, might, without repaging or other change except in the cover, be also broken up into several subject groups which would be made available to individuals not desiring the complete service. The following subject grouping into five "reprint" parts has been adopted by the board for 1939.

1. *Abstracts of General Biology* to include general biology, biography-history, bibliography, evolution, cytology, genetics, biometry and ecology; price $4.

2. *Abstracts of Experimental Animal Biology* to include animal physiology, nutrition, pharmacology, pathology, anatomy, embryology and animal production; price $9.

3. *Abstracts of Microbiology and Parasitology* to include immunology, bacteriology, viruses, parasitology, protozoology and helminthology; price $5.

4. *Abstracts of Plant Sciences* to include phytopathology, plant physiology, plant anatomy, paleobotany, systematic botany, agronomy, horticulture, forestry, pharmacognosy and pharmaceutical botany; price $6.

5. *Abstracts of Animal Sciences* to include paleozoology, parasitology, protozoology, helminthology, systematic zoology and economic entomology; price $6.

The subscription price for the complete volume 13 for 1939 will be $25 to individual subscribers and institutions alike, the Board of Trustees announces. The Board explains that the proposed plan involves merely the lifting out (without resetting of type or renumbering of the abstracts) of the sections appertaining to the subject group concerned and binding them in a separate cover which would bear the appropriate subtitle. The complete index, going to all subscribers, would still preserve most of the desirable long-range features of the full service, especially so since all subscribing libraries and institutions will want *Biological Abstracts* in its entirety. The Board believes that the new plan will meet the requirements alike of specialization and general survey at prices that will be found feasible by both biologists and libraries.

Each of the biological societies concerned is being invited by the Board to set up a committee which will be effective in fixing the editorial policies and standards of the *Abstracts* within its respective field.

LOS ANGELES INSPECTORS MEETING

The annual meeting of the Los Angeles County Agricultural Inspectors Association was held in Alhambra, Calif., September 23, 1938.

There was an attendance of 175, composed of inspectors, agricultural commissioners, and state, federal and commercial entomologists, as well as representatives of various organizations interested in some phase of pest control.

It was of special interest that the guest speaker of the evening, Dr. Lee A. Strong, began his career as an inspector in the district in which the meeting was held.

LEAD TOLERANCE CHANGED

A press release from the U. S. Department of Agriculture includes the following statement:

"Following receipt from the Treasury Department of a statement that investigations by the Public Health Service indicate that the health of consumers will not be endangered by the change, the Secretary of Agriculture has issued notice that the quantity of lead residue permitted on fruits shipped interstate will be raised to 0.025 grain per pound of fruit. The lead tolerance previously enforced under the Food and Drugs Act was 0.018 grain per pound. The tolerances for arsenic and fluorine residue remain unchanged at 0.01 grain per pound."

ORIENTAL RAT FLEA IN MIDDLE WEST

The magazine, *Science*, for November 4, 1938, contains a note in which H. E. Ewing, U. S. Department of Agriculture, Bureau of Entomology and

Plant Quarantine, and Irving Fox, Iowa State College, Ames, report the occurrence of the oriental rat flea, *Xenopsylla cheopis* (Rothsch.), in Illinois and Ohio, two states in which it had not previously been reported. This flea, the chief transmitter of bubonic plague to man, was first reported from the interior of the United States by R. L. Roudabush and E. R. Becker in *Science* **80**: 97, 1934.

RECENT MEETINGS

The Eastern Branch of the American Association of Economic Entomologists convened at Baltimore, Md., November 17–18. An account of the meeting will appear in the April issue of this publication.

The National Pest Control Association held its annual meeting in the Hotel Fontenelle, Omaha, Neb., October 24–26. A major feature of the three-day program was the pest clinics, dealing with problems commonly confronting pest control operators.

FUTURE MEETINGS

The Cotton States Branch of the American Association of Economic Entomologists will hold its 1939 annual meeting at Tampa, Fla., Feb. 21–23. Selected as headquarters, the Hillsboro Hotel has granted special rates of $2.50 and up for delegates. Secretary Oliver I. Snapp of the Cotton States Branch warns that, because of the overcrowded condition of Florida cities during the tourist season, reservations should be placed early by those who contemplate attending the meeting. Unusual features are in the course of preparation, Secretary Snapp announces.

The Third Annual Pest Control Operators Conference will he held at Purdue University, Lafayette, Indiana, January 16–20, 1939.

PROCEEDINGS OF THE THIRTEENTH ANNUAL MEETING
COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
Jung Hotel, New Orleans, La., February 3–5, 1938

The Thirteenth Annual Meeting of the Cotton States Branch of the American Association of Economic Entomologists was held at New Orleans, La., February 3, 4 and 5, 1938. The sessions on February 4 were held jointly with the Louisiana Entomologists, a branch of the Louisiana Academy of Science, in the Roosevelt Hotel, with H. L. Kearney, President of that Academy, presiding. The attendance was larger than that of any previous meeting of the Branch, there being 150 names on the attendance record. Sessions were held on three days and three nights.

The program included symposia on Forest Insects, led by Thomas E. Snyder, and on Citrus Insects and Citrus Spraying, led by Herbert Spencer. A number of growers and others interested in citrus growing in Louisiana attended the latter symposium. Conferences held during the meeting were those on thrips with C. O. Eddy, leader, the velvetbean caterpillar, *Anticarsia gemmatiles* (Hbn.), as a pest of soybeans with C. M. Packard, leader, and the sweet potato weevil with C. O. Eddy, leader. The symposia and conferences prompted considerable informal discussion of the subjects presented. The March of Time film, "Pests of 1937," and U. S. Department of Agriculture films on the white-fringed beetle, periodical cicada and honeybee were shown. The program included visits to the entomological section of the Museum of Tropical Diseases of Tulane University and the sulfur wells south of New Orleans.

Forty-seven papers were presented during the meeting. These were classified as follows:

Insects attacking cotton	11
Insects attacking animals and man	8
Insects attacking fruits and nuts	6
Insects attacking truck crops	6
Insects attacking tobacco	4
Insects attacking forage crops	3
Insects attacking rice and sugarcane	2
Insecticides	2
Miscellaneous	5

The President of the American Association of Economic Entomologists, J. J. Davis, attended the meeting and extended greetings from the parent Association. His address to the Branch dealt with the importance of and achievements in entomology, advancement in extension entomology and pest control operators, the next annual meeting of the parent Association in Richmond, Va., and the change in the make-up of the JOURNAL OF ECONOMIC ENTOMOLOGY. Greetings to the Branch were read from Dr. L. O. Howard, dean of American entomologists.

The annual address of the Chairman of the Branch was ably presented by W. E. Dove on the morning of February 3 and discussed by C. O. Hopkins. A number of interesting exhibits, especially one on the white-fringed beetle, were installed in a spacious hall adjoining the meeting room.

An informal "get-together" smoker was enjoyed on the night of February 2 in the Jung Hotel and the annual banquet, with an elaborate floor show followed by a dance, was given on the night of February 4 in the La Louisiane, a famous restaurant in the French quarter of New Orleans.

BUSINESS PROCEEDINGS

The meeting was called to order by Chairman W. E. Dove at 9:00 a.m. on February 3 in the Jung Hotel at New Orleans. The following were present:

Allen, N.
Anderson, W. E.
Arant, F. S.
Bailey, L. H.
Balzer, A. I.
Barber, E. R.
Barber, T. C.
Barrett, W. L., Jr.
Becnel, I. J.
Benson, R. F. A.
Bentley, G. M.
Berly, J. A.
Bieberdorf, G. A.
Bond, G. L.
Brock, J. A.
Brody, A. L
Brubaker, R. W.
Bunton, P. B.
Bynum, E. K.
Campbell, R. E.
Cartwright, O. L.
Catchings, T. F.
Cavanagh, A. E.
Chamberlin, F. S.
Charpentier, L. J.
Christian, M. B.
Clark, J. C.
Cockerham, K. L.
Collins, R. C.
Colmer, R. P.
Corliss, J. M.
Cotton, R. T.
Creighton, J. T.
Curl, L. F.
Davis, J. J.
Dawson, J. C.
Deen, O. T.
Del Curto, J. M.
Dietz, H. F.
Douglass, N. L.
Douglas, W. A.
Dove, W. E.
Dunnam, E. W.
Dutton, J. R.
Easter, S. S.
Eddy, C. O.
Ellisor, L. O.
English, L. L.
Fenton, A.
Floyd, E. H.
Gaddis, B. M.
Gaines, J. C.
Gaines, R. C.
Gayden, J. H.
Gilmore, J. U.
Gladney, H.
Glick, P. A.
Gold, L. R.
Graham, L. T.
Grimes, M. L.
Haley, W. E.
Hammond, G. H.
Hamner, A. L.
Hathaway, E. S.
Hetrick, L.
Hixon, E.
Hixon, H.
Hollingsworth, H. S.
Holloway, T. E.
Hopkins, C. O.
Hood, R. V.
Horsfall, J. L.
Ingram, J. W.
Jones, M. P.
Kearney, H. L.
Kislanko, J. P.
Langston, J. M.
Lee, H. W.
Lee, J. E.
Lindquist, A. W.
Livingston, B. P.
Loftin, U. C.
Long, Huey, Jr.
Lott, E.
Lyle, C.
Madden, A. H.
Martin, G. C.
Mathes, R.
Maxwell, J. M.
Mayer, L. A.
McGregor, S. E.
McKay, W. O.
Meadows, C. M.
Mecom, W. H.
Montgomery, J. H.
Moreland, J. H.
Moreland, R. W.
Morrow, J. E.
Nickels, C. B.
Osterberger, B. A.
Packard, C. M.
Peets, N. D.
Peterson, P. D.
Pierce, W. C.
Price, R. C.
Rainwater, C. F.
Reed, W. D.
Richardson, C. H.
Roark, R. C.
Roberts, J. H.
Roberts, W. C.
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Stracener, C. L.
Thomas, F. L.
Travis, B. V.
Watts, J. G.
White, W. H.
Wingfield, E. D.
Wisecup, C. B.
Wood, J. R.
Woodworth, C. W.
Wright, M.
Young, H. C.
Young, H. D.
Young, M. T.

The report of the Secretary-Treasurer was then read and approved subject to the audit of the auditing committee.

REPORT OF SECRETARY-TREASURER

Balance on hand February 16, 1937		$200.54
Refund from parent Association for postage printing and telegram during year ending February 15, 1937		18.36
Contributions		7.00
1935 annual dues from 2 members		2.00
1936 annual dues from 5 members		5.00
1937 annual dues from 30 members		30.00
1938 annual dues from 3 members		3.00
Interest on deposit in Savings Department of First National Bank, Atlanta, Ga.		1.67
Paid Out:		
Expense for annual meeting in San Antonio, Tex. (By action of Executive Committee)	$ 69.89	
Stamped envelopes and stamps	14.72	
Mimeographing paper and blank envelopes	2.55	
Printing announcements and programs of annual meeting	10.25	
Badges for annual meeting	7.17	
	$104.58	$267.47
Balance on hand February 3, 1938	$162.89	

The number of members in the Cotton States Branch on December 31, 1937, was 187. There was a net increase of 13 members during the year, after the removal of the names of those who had moved out of the Branch territory or were dropped by the parent Association for non-payment of dues. This is the first year since 1930 that the Branch has shown a net increase in membership. There was a gradual decrease in membership between 1930 and 1935.

The number of members by states on December 31, 1937, was as follows: Texas, 52; Louisiana, 26;

Florida, 25; Mississippi, 19; Georgia, 17; North Carolina, 12; South Carolina, 12; Alabama, 7; Tennessee, 7; Arkansas, 6; and Oklahoma, 4. The following states showed net increases during the year: Georgia, 6; Texas, 6; Florida, 3; Louisiana, 3; North Carolina, 2; Alabama, 1; Arkansas, 1. Net decreases during the year were as follows: Mississippi, 6; South Carolina, 2; and Tennessee, 1. There was no change in the number of members in the state of Oklahoma during the year. There are several hundred entomological workers in the 11 Cotton States who are not members of the American Association of Economic Entomologists, and members of the Branch are requested to urge these men to file application for membership in the parent Association. Lists of these workers will be gladly furnished upon application to the Secretary of the Cotton States Branch.

On December 6, 1937, the Secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in New Orleans, La., February 3–5, 1938. The program for that meeting was mailed to each member on January 18, 1938. The proceedings of the twelfth annual (San Antonio, Tex.) meeting of the Cotton States Branch were published in the April, 1937 (Vol. 30, No. 2), issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, and a report on the eleventh annual (Jackson, Miss.) meeting was published in the February, 1937 (Vol. 30, No. 1) issue of that JOURNAL.

Annual dues in the Cotton States Branch are $1.00. Thirty-eight of the 187 members have paid dues for 1937, and only three members have paid their 1938 dues, which are now payable.

Chairman Dove appointed the following committees: Auditing, K. L. Cockerham, A. W. Lindquist and R. C. Gaines; Resolutions, John T. Creighton, C. O. Eddy and Clay Lyle; Nominations, W. E. Anderson, F. L. Thomas and B. P. Livingston; Publications, Oliver Snapp, Roy Melvin and Herbert Spencer.

FINAL BUSINESS

Chairman Dove called for the report of committees.

The Auditing Committee reported that the books and accounts of the Branch had been carefully examined and found to be correct. This report was then accepted by motion and vote and a certificate given to the Secretary-Treasurer.

The Publications Committee requested authors to send their papers direct to the Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY in cases where they were not ready for publication immediately after being read.

The following resolutions were duly adopted after the reading of the report of the Committee on Resolutions and the Secretary sent them to the parties concerned:

WHEREAS, The thirteenth meeting of the Cotton States Branch of the American Association of Economic Entomologists has been held in the city of New Orleans on February 3, 4 and 5, 1938; the meeting being held in conjunction with the Louisiana Entomologists; and

WHEREAS, The several sessions were well attended, and many excellent talks and papers were presented; and

WHEREAS, the meeting has been deemed an unusual success by the membership of the Cotton States Branch and their friends; and

WHEREAS, there have been many contributing agencies to the successful creation and completion of an interesting program; therefore,

Be It Resolved, That the Cotton States Branch extend its thanks and appreciation:

1. To the officers of the Cotton States Branch for the creation of a splendid program and the efficient handling of the various sessions, and to our 1937–38 Chairman, Dr. W. E. Dove, for his able address.

2. To the Louisiana Entomologists for the arrangements that were made, which tended to facilitate the smooth movement and completion of the program.

3. To the wives of the Louisiana Entomologists for the many interesting things that they planned for visiting ladies.

4. To Professor J. J. Davis President of the American Association of Economic Entomologists for his attendance and talk.

5. To the managements of the Jung and Roosevelt hotels and their entire working personnel for the cordial, courteous and efficient service during the course of the convention.

6. To Dr. Faust and his colleagues, of the Tulane University medical staff, for permission to visit their exhibits, and for the instructive individual discussions during the course of the tour.

7. To the local committee for all special arrangements.

8. To Dr. L. O. Howard, dean of American entomologists for his cordial letter of greeting.

9. To members of the press of the city of New Orleans for their accuracy and effective release of the news.

10. And to the New Orleans Floral Association for providing the bouquet of flowers.

Be It Further Resolved, that our Secretary be instructed to incorporate these resolutions in the permanent proceedings of the Cotton States Branch of the American Association of Economic Entomologists.

The Nominations Committee recommended the following names for officers during the ensuing year: For Chairman, C. O. Eddy, Baton Rouge, La., for Vice Chairman, W. G. Bruce, Dallas, Tex. By motion and vote the Secretary was instructed to cast a single ballot for the unanimous election of these officers and Past-Chairman Clay Lyle escorted Dr. Eddy to the chair where he was duly installed as Chairman of the Cotton States Branch. Secretary-Treasurer Oliver I. Snapp was elected in 1937 for a three-year term.

According to the order of meeting adopted by the Branch in 1936, the next annual meeting must be held in a city in the southeast. By motion and vote it was decided to hold the 1939 meeting in the state of Florida, the time and city to be selected later by the Executive Committee.

The Secretary offered suggestions for the improvement of programs for future meetings. Details will be omitted in the presentation of future papers which will probably be restricted to a summary or abstract followed by a discussion of each paper.

The annual address of the Chairman of the Cotton States Branch was given by W. E. Dove immediately following the business session on February 3. This was followed by the first session for the presentation of papers with Dr. Dove presiding.

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